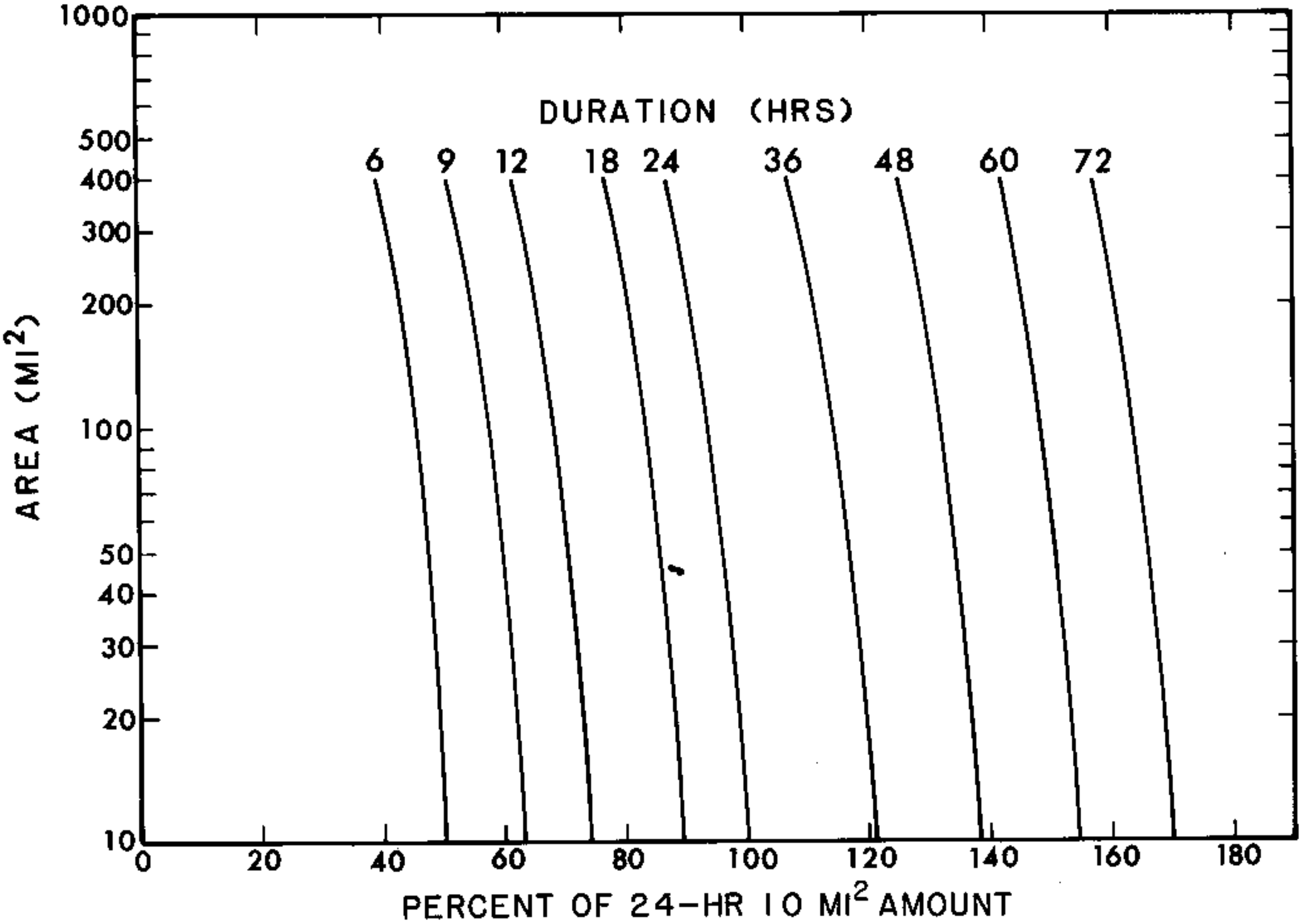


Figure 30.—Depth-area-duration relation for southeast Alaska probable maximum precipitation.

f. Arrange the values from step e. in any sequence that may be hydrologically critical so as not to undercut PMP values for any duration.

g. Determine percent reduction from table 16 if other than all-season PMP is required.

3.8.4 Areal Distribution of Probable Maximum Precipitation

In general, uniform distribution of PMP is suggested for PMP over basins in southeast Alaska. However, where fixed significant control by orography exists, we recommend that the user distribute the PMP in line with such orographic control. As a yardstick for judgment on whether orographic controls are significant, we suggest that, if 24-hr 10-mi^2 (26-km^2) PMP varies by as much as 25 percent within the boundaries of a basin, the user should consider orographic control as significant and determine the areal distribution of isohyetal values within the basin.

If orographic control is significant on the areal distribution of PMP in the basin, the "first approximation" distribution should be accomplished as follows:

1. The average 24-hr, 10-mi^2 (26-km^2) PMP is determined for the basin. This average value is assigned 100 percent.

2. A set of analyzed 24-hr, 10-mi^2 (26-km^2) lines across the basin are then labeled in percents on the basis of the mean value (from step 1) being the 100-percent value.

3. The percent lines of step 2 need to be relabeled to give the basin average PMP. This is done by assigning the basin average PMP, in inches, to be the 100 percent line of step 2 and assigning values in inches to the remaining lines from products of the percentages by the basin mean PMP (in inches). These values are now orographically controlled labels of 24-hr basin PMP.

4. From step 3, incremental percents for obtaining labels for any desired increments of PMP are obtained by reading appropriate ratios from figure 30 at the area of the basin, constructing a smooth depth-duration curve if necessary, to obtain all desired ratios, and obtaining incremental values from accumulative percents. Appropriate percents are then applied to the labels in step 3 to obtain incremental labels.

In the procedure just outlined, the user may obtain a result that produces an unacceptable depth-area relation. Using the 6-hr labels as a test, a depth-area curve should be constructed, converted to a percentage depth-area curve, and compared with the PMP depth-area curve for figure 30. If the resulting depth-area curve, when tied into the PMP curve at the basin area, results in any values for smaller areas exceeding the PMP values, the user must then make some "trial and error" downward adjustment in the values in previous steps until exceedance of PMP at areas smaller than the basin are avoided. However, adopted values for areas smaller than the total basin area may be a modest amount below the PMP amounts for these smaller areas. Any required adjustments at the 6-hr duration may then be applied to other durations to assure consistency throughout all durations.

4. GENERALIZED SNOWMELT CRITERIA

4.1 Introduction

This chapter provides generalized criteria for determining snowmelt based upon varying placements of the 3-day PMP. These criteria include temperatures, dew points, wind and snowpack, along with elevation variations of each element. We first give brief background support for each of the separate criteria. Then, the necessary generalized charts and schematics are presented along with a stepwise procedure for obtaining the necessary estimate of values of each element for a basin. For clarification to the user, an example of the determination of snowmelt criteria is presented.

This generalized approach may smooth over differences in particular regions that the user knows exist and wishes to retain. For example, the generalized elevation contours of figure 5 may oversimplify the topography in many basins for snowmelt computations. In such cases, the user may use more detailed topographic maps in obtaining values of the various snowmelt parameters. Also, in certain areas, such as around Ketchikan and Juneau where more information than in general is available on MAP variations, the user, instead of using data from the generalized MAP chart (fig. 6) may judiciously make use of more detailed MAP variations that he confidently feels are warranted.

4.2 Temperature Criteria

Temperature criteria are provided for the 3-day PMP storm and for a period of 5 or more days prior to the PMP event. In line with prior precedent from previous studies (U.S. Weather Bureau, 1961, 1966, 1967, National Weather Service 1977) dealing with Alaskan snowmelt criteria, two sets of criteria are developed. One is the high-temperature sequence; the other, the high-dew-point sequence. The first is tied to a synoptic event where high pressure and clear skies (continental influence) predominate. This high-temperature sequence used prior to 3-day PMP has a large temperature-dew point spread. The other (the high-dew-point sequence) is derived from a maritime regime of onshore flow. This regime gives less extreme temperatures (i.e., more cloudiness, less sunshine) but higher dew points than does the high-temperature sequence. Somewhat different elevation variations are given for the two contrasting temperature sequence types (sec. 4.2.2.4).

4.2.1 Temperature Criteria During the 3-Day Probable Maximum Precipitation

During the 3-day PMP storm, saturated conditions are assumed in the sense that mean daily temperatures and dew points are the same. Therefore, during the 3-day PMP the adopted temperatures come directly from the dew points that are the maximum 12-hr persisting dew points for the season and location. (See dew-point criteria, sec. 4.3.)

4.2.2 Temperature Criteria Prior to 3-Day Probable Maximum Precipitation

Temperature criteria for snowmelt prior to PMP require:

a. Mean midmonthly temperature charts.

b. A sequence of daily temperature departures for up to 5 or more days prior to PMP for the high-temperature case.

c. A sequence of daily temperature departures for up to 5 or more days prior to PMP for the high-dew-point case.

d. Elevation variations of temperature criteria for both categories b. and c.

4.2.2.1 Mean Temperature Charts Figure 31 shows analyzed midmonth temperature charts for March through June. The primary data used for these analyses were 30-yr normal monthly temperatures (1941-70) for nine stations in southeast Alaska (Environmental Data and Information Service, 1973). We attempted to obtain a reasonable consistency in changing orientation as the offshore warm source in April changed to an onshore (inland) warm source in June with May the primary transitional month. The March map (fig. 31) shows an important characteristic for the months of snowpack accumulation - that is colder temperatures inland away from the coast.

4.2.2.2 High-Temperature Case Departures A consideration of extreme temperature departures for south coast and southeast Alaska locations resulted in the conclusion that the basic synoptic type for the highest temperatures is the same as previously determined for the Alaskan Interior Region (U.S. Weather Bureau, 1966). This consists of large-scale domination by high pressure with relatively light winds, above normal sunshine, high temperature, and relatively low humidities.

Numerous high-temperature sequences at southeast Alaskan stations were summarized with tie-ins with previous specific estimates of Alaskan snowmelt criteria for the south coast and other locations. The following are to be noted:

a. Of the five warmest Aprils at Annette and Juneau, 1953 was the warmest April for Annette and the second warmest April for Juneau, while 1960 was the third warmest April at both locations.

b. Warm Mays that also were warm along the south coast of Alaska were those of 1953 and 1960, while similar warm Junes were those of 1953 and 1958. The number of cases, especially in May and June, where southeast Alaska is warm during the same periods that the south coast is warm supports previous conclusions on similar synoptic types as previous Alaskan basin estimates.

c. May 1960's temperatures at Juneau show how high temperatures typical for a number of days prior to rain (due to the high-pressure, continental-type weather control) gradually give way to a maritime rain-producing regime. An abrupt change of prevailing type is unrealistic. Other southeast Alaska warm spells also confirmed prior conclusions on continental influences for the warmest temperature cases.

Departures in temperatures for increasing durations were determined from many months comprised of unusual warm spells. The adopted criteria for the warm temperature cases come from the summation of departures from unusual warm spells such as those shown in table 18. For this study for the high-temperature sequence, we have adopted a value of +6°F (3.3°C) above normal for the first 3 days prior to PMP, +7.5°F (4.2°C) for the 4th day, and +12.5°F (6.9°C) for the 5th day and +10°F (5.6°C) above normal for the 6th through 10th days. This gives a 10-day average departure of about +9°F (5°C).

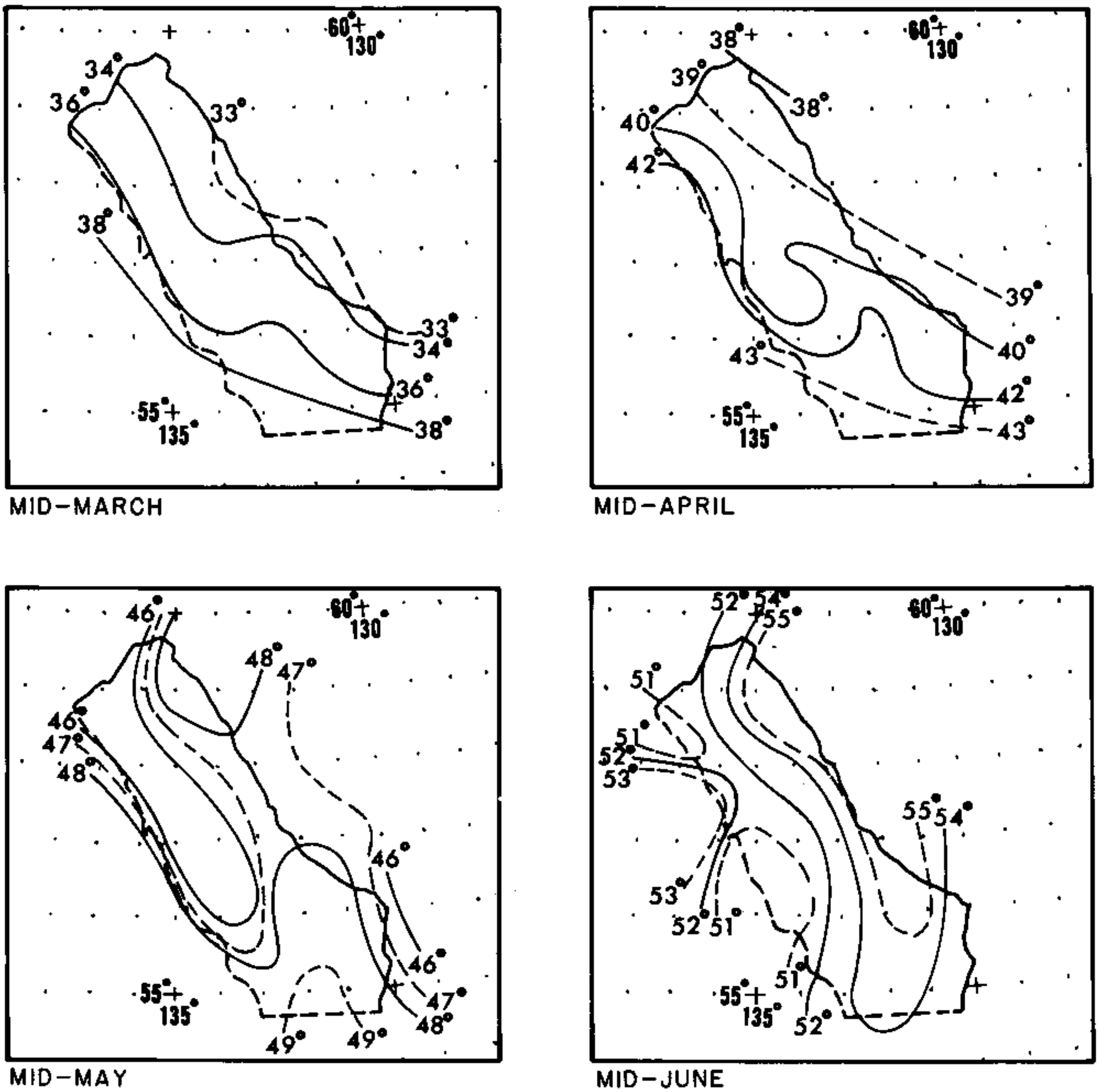


Figure 31.--Mean sea-level temperature (°F) for study area mid-March to mid-June

Table 18.--Summation of temperature departures (°F) from unusual warm spells

Station	Date	Day prior to maximum temperature 1	2	3	4	5	6	7	8	9	10	Highest daily temp. (°F)
Ketchikan	5/10-12/42	13*	11	10	-	-	-	-	-	-	-	61
Ketchikan	5/18-27/58	16	14	12	10	10	10	10	10	8	8	68
Ketchikan	5/28-6/7/56	12	12	11	9	9	10	9	8	8	9	66
Annette	4/21-30/58	12	11	11	11	11	11	10	10	10	9	57
Annette	4/1-6/58	14	13	11	9	8	9	-	-	-	-	54

*All values are rounded off to nearest whole degree F. To convert to °C use equation $C = \frac{5}{9}(F - 32)$

A plot was made of many cases where a 1-day temperature departure of 10°F (5.6°C) or more comprised a sequence of positive temperature departures. The mean relation and envelopes of the data are shown in figure 32. From this figure, support can be seen for a generalization that allows for some lessening of the temperature departures for several days following the day of most extreme departure. Synoptically, such a trend is realistic as one goes from the large temperature departures toward a rainy spell which we must postulate for tying into any above-normal temperature sequence with the 3-day PMP.

4.2.2.3 High Dew-point Case Departures. A survey of high-dew-point cases indicated a rather firm tendency for decrease in the magnitude of the positive temperature departures for the high-dew-point cases when compared to the high-temperature cases. This confirmed prior work done with temperature and dew-point data from the south coast region for earlier specific Alaskan basin estimates. These data are significant in adopting temperature criteria for high-dew-point situations, since the adopted criteria is to be used prior to the occurrence of 3-day PMP. Thus, for this study for the high-dew-point case, the temperature departure we adopt for the first 3 days prior to the 3-day PMP is held to +2°F (1.1°C) for each day, increasing to +3°F (1.7°C) the 4th day prior to the beginning of the PMP and to +5°F (2.8°C) for 5 to 10 days prior to PMP (see fig. 33).

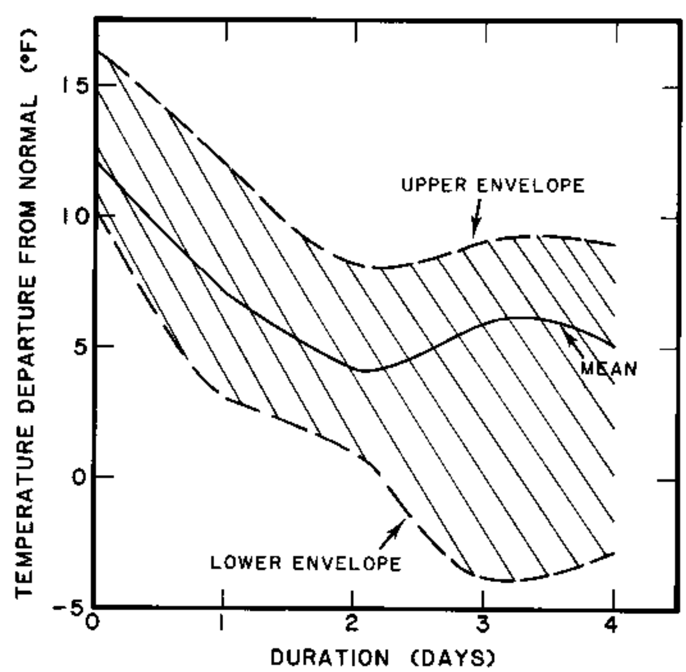


Figure 32.--Temperature departures in relation to peak daily temperatures.

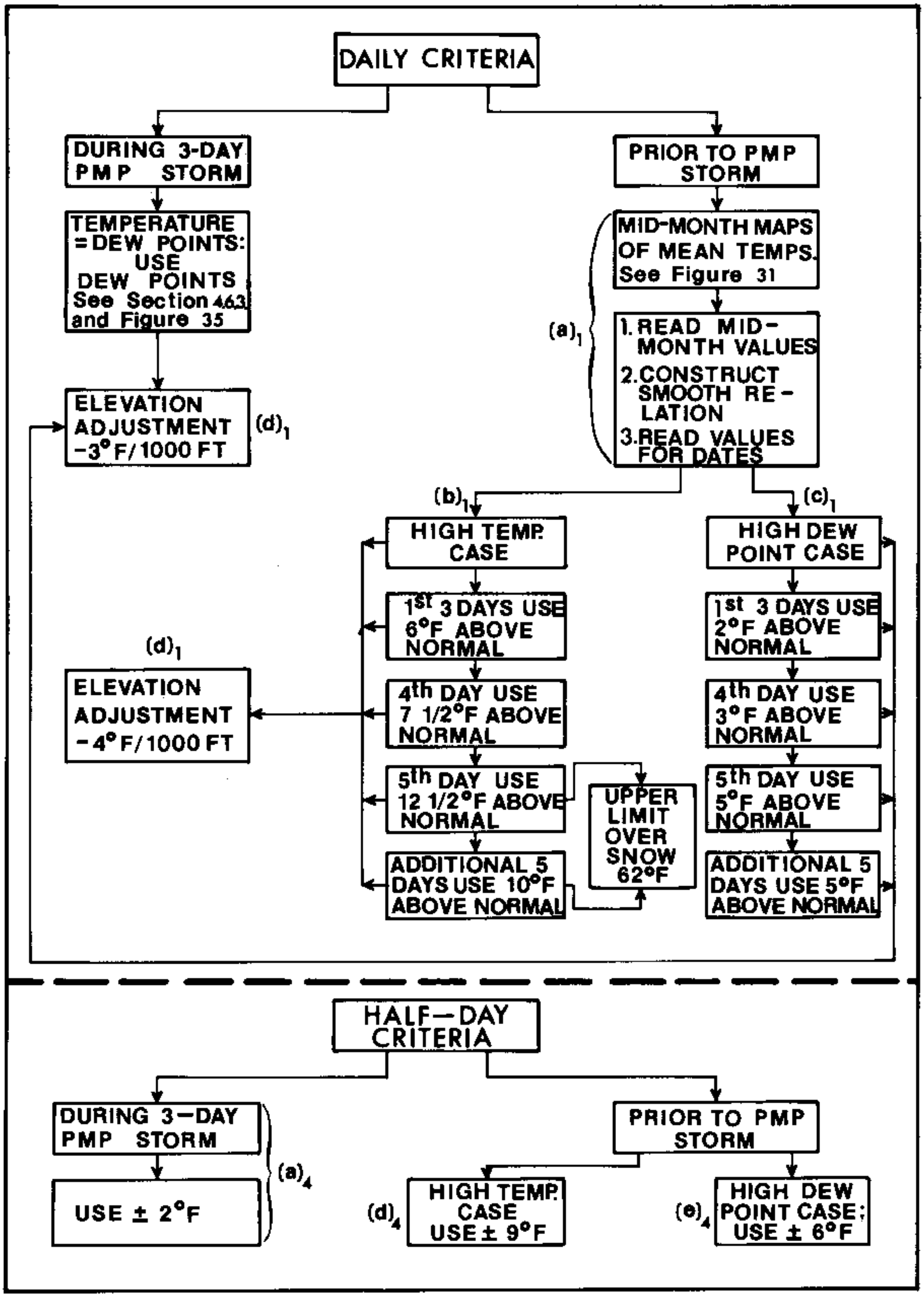


Figure 33.—Schematic for snowmelt temperature criteria.

4.2.2.4 Elevation Variations. In a generalized PMP and snowmelt study for the Yukon (U.S. Weather Bureau, 1966), a study of upper-air soundings for high-temperature situations led to the adoption of a criteria of -4°F/1,000 ft (-2.2°C/305 m) for such situations. Thus, for the high-temperature case, we adopted a lapse rate of -4°F/1,000 ft. (-2.2°C/305 m). This contrasts to a vertical lapse rate of -3°F/1,000 ft (-1.7°C/305 m) for the saturated 3-day PMP period.

Earlier specific PMP studies for the south and southeast coasts of Alaska helped firm up the adoption for this study of a lapse rate of -3°F/1,000 ft (-1.7°C/305 m) for the high-dew-point snowmelt case. Additional checks on lapse rates in southeast Alaska situations done for this generalized study supported the reasonableness of these separate criteria for vertical lapse rates in the maritime vs. the continental broadscale weather types.

4.2.3 Upper Limit of Mean Daily Temperature Over Snow Cover

In the Yukon study (U.S. Weather Bureau, 1966) an upper limit to mean daily temperature over snow cover of 62°F (16.7°C) was determined to be realistic. This same limit is adopted for our study area. Therefore, wherever the application of temperature criteria results in a mean daily temperature above 62°F (16.7°C) the temperature(s) should be reduced to the maximum allowable daily mean temperature over snow cover of 62°F (16.7°C).

4.2.4 Half-Day Temperature Criteria

The user may wish to divide daily criteria into half-day criteria. We recommend the following half-day temperature criteria:

1. During the 3-day PMP event, use ± 2°F (1.1°C).
2. Prior to the 3-day PMP event with high-dew-point case, use ±6°F (3.3°C).
3. Prior to the 3-day PMP event with high-temperature case, use ±9°F (5.0°C).

Some of the support for the adopted half-day criteria comes from prior studies done in Alaska. Furthermore, as part of the present study additional summations of high-dew-point and high-temperature cases support the adopted spectrum of half-day values. For example:

a. For a May 18-27, 1958, warm period at Annette, the diurnal range in temperature was 18°F (10.0°C). For a warm spell, April 21-30, 1931, the range in temperature averaged 24°F (13.3°C).

b. For May and June cases of high-dew-point situations at Annette accompanied by 24-hr precipitation of 2 in. (50.8 mm) or more, an approximate 12°F (6.7°C) range in temperatures was suggested.

c. An average of the difference between maximum and minimum temperatures for warm months for northern, central, and southern portions of southeast Alaska did not show any need for regional differences. Hence, the same high-low spreads (or 1/2-day breakdowns of mean daily temperature) were adopted for all of southeast Alaska covered in the present study.

4.2.5 Schematic of Temperature Criteria

A schematic (fig. 33) was made showing the basic snowmelt temperature criteria discussed in previous sections. This schematic, together with the required figures, provides a stepwise method of obtaining temperature criteria for snowmelt for any basin in southeast Alaska. Letters in parentheses refer to steps discussed in section 4.6.

4.3 Dew-Point Criteria

As in the generalized snowmelt temperature criteria (sec. 4.2), two sequences are needed for the dew-point criteria in addition to the dew-point sequence during the PMP storm. One sequence concerns the dew points that go with the high-temperature case; the other sequence concerns the dew points that go with the high-dew-point case. The dew-point criteria for both the high-temperature and the high-dew-point sequences are developed in the form of increments (in °F) to subtract from the respective temperature criteria, determined from the use of the schematic of figure 33 and other necessary figures.

4.3.1 Dew-Point Criteria During the 3-Day Probable Maximum Precipitation

Basic dew-point criteria are needed for the 3-day PMP. As pointed out in section 4.2.1, the daily temperature criteria for the 3-day PMP are defined by the basic daily dew-point criteria since saturation is assumed. For the purpose of obtaining dew points (and, therefore, temperatures) during the 3-day PMP, a series of dew-point charts was developed (fig. 34). The monthly dew-point charts were derived from the following:

a. 12-hr persisting dew-point charts for Alaska by months developed originally for the Yukon Project (U.S. Weather Bureau 1966).

b. Updating of the dew-point charts referred to in a. (for the portion of the year needed in this report) from smoothed seasonal adjustments based upon a precipitable-water analysis for Alaskan stations (Lott 1976).

c. The relation of 12-hr to daily dew points and the variation of daily dew points within the 3-day PMP comes from previously adopted durational variation of dew points for Alaska.

In order to obtain the appropriate maximum 24-hr dew-point for a specific placement of the PMP, the user reads a sufficient number of midmonth maximum 24-hr dew points based upon the chosen date for placement of the 3-day PMP. For the second day subtract 2°F (1.1°C) from the maximum value, and for the third day subtract 4°F (2.2°C).

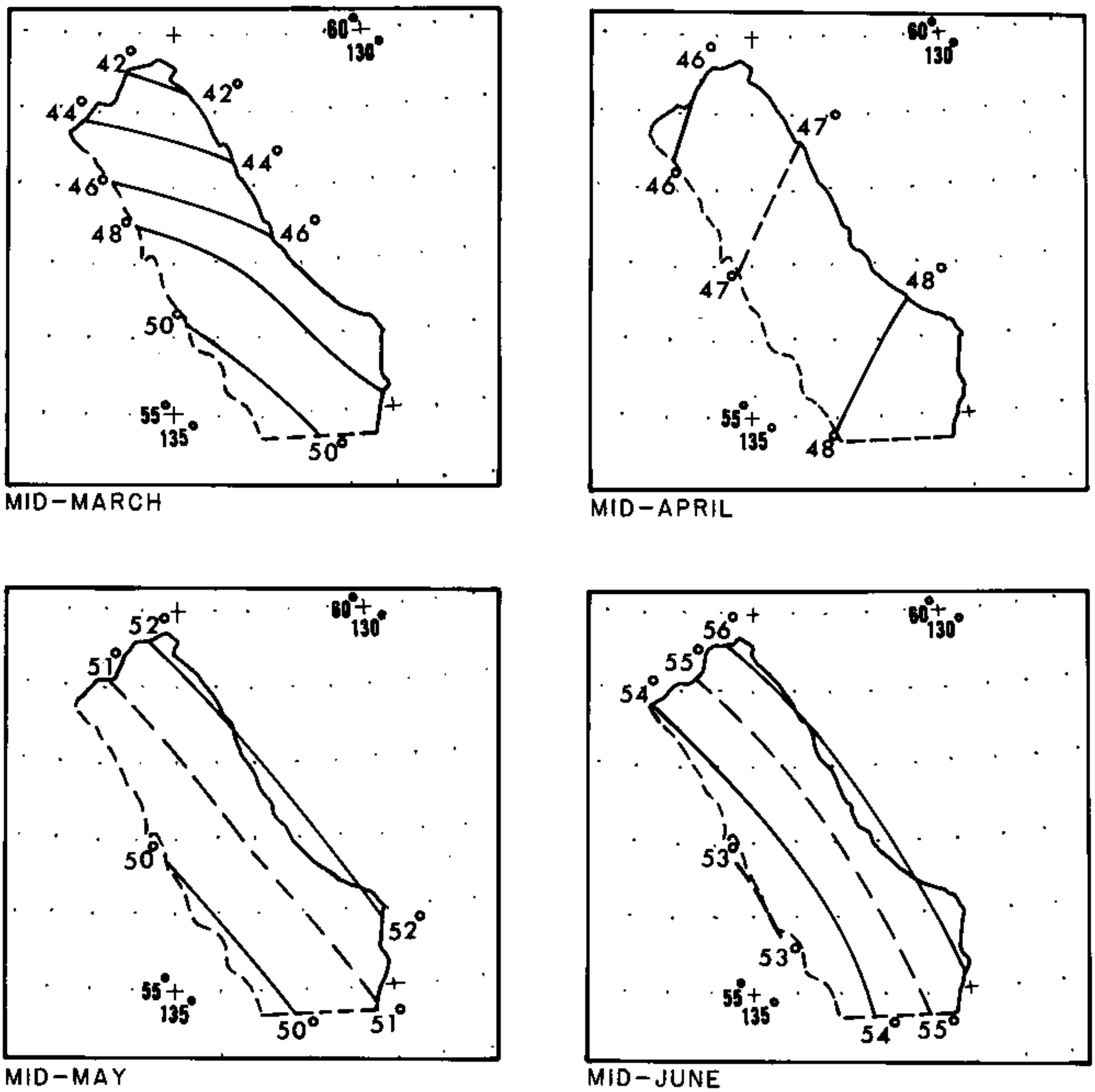


Figure 34.--24-hr sea-level dew-point (°F) for study area-mid-March to mid-June.

4.3.2 Dew-Point Criteria for High-Temperature Sequence Prior to 3-Day Probable Maximum Precipitation

Dew-point criteria to go with the prior-to-3-day PMP high-temperature sequence are developed by means of temperature-dew-point spreads defined by high-pressure dominated, high-insolation, low-wind situations that produce the high-temperature sequence. The offshore flow characteristic of these situations results in relatively low humidities, or large temperature-dew-point spreads. The adopted temperature-dew-point spread for the high-temperature sequence is 13°F (7.2°C) for the first 3 days, increasing to 18°F (10°C) for days prior to this (see fig. 35). The 18°F (10°C) spread is continued out to the 10th day before the beginning of the 3-day PMP, if criteria are needed for this many days.

A typical example in support of the adopted dew-point criteria is for May 1942. During May 1942, the temperature at Juneau averaged 5.2°F (2.9°C) above normal with the warmth concentrating in the last two-thirds of the month when only 0.84 in. (21 mm) of precipitation occurred. Of 16 days on which the dew point was ≥40°F (4.4°C), 12 were consecutive. For the 16 days, the average temperature-dew-point spread was 10°F (5.6°C) while on 8 days the high-low temperature spread was ≥18°F (10°C).

4.3.3 Dew-point Criteria for High-Dew-Point Sequences Prior to 3-Day Probable Maximum Precipitation

In generalizing the temperature-dew-point spread for the high-dew-point case, high-dew-point situations at Annette were investigated for days in May and June. These suggested an average temperature-dew-point spread of 5°F (2.8°C) for a short sequence. The adopted criteria were 4°F (2.2°C) for the first 3 days prior to PMP, 6°F (3.3°C) for the fourth day, and 8°F (4.4°C) for the fifth day or more prior to the PMP (fig. 35).

4.3.4 Elevation Variation of Dew Points

The adopted separate temperature elevation variations discussed in section 4.2.2.4 also apply to the separate dew-point criteria -- that is, a -4°F (-2.2°C) per 1,000-ft (305-m) lapse rate for the dew points that go with the high-temperature criteria and -3°F (-1.7°C) per 1,000 ft (305 m) for the dew points that go with the high-dew-point criteria.

4.3.5 Upper limit

If, in accordance with section 4.2.3, a daily temperature must be reduced from a higher value to 62°F (16.7°C), then the same reduction should be applied to the accompanying dew point also. This would ensure that the adopted temperature-dew-point spread is retained.

4.3.6 Half-day dew-point criteria

The following half-day dew-point criteria are recommended:

1. During the 3-day PMP event, use ±2°F (1.1°C).

2. Prior to the 3-day PMP event with high-temperature case, use ±3°F (1.7°C).

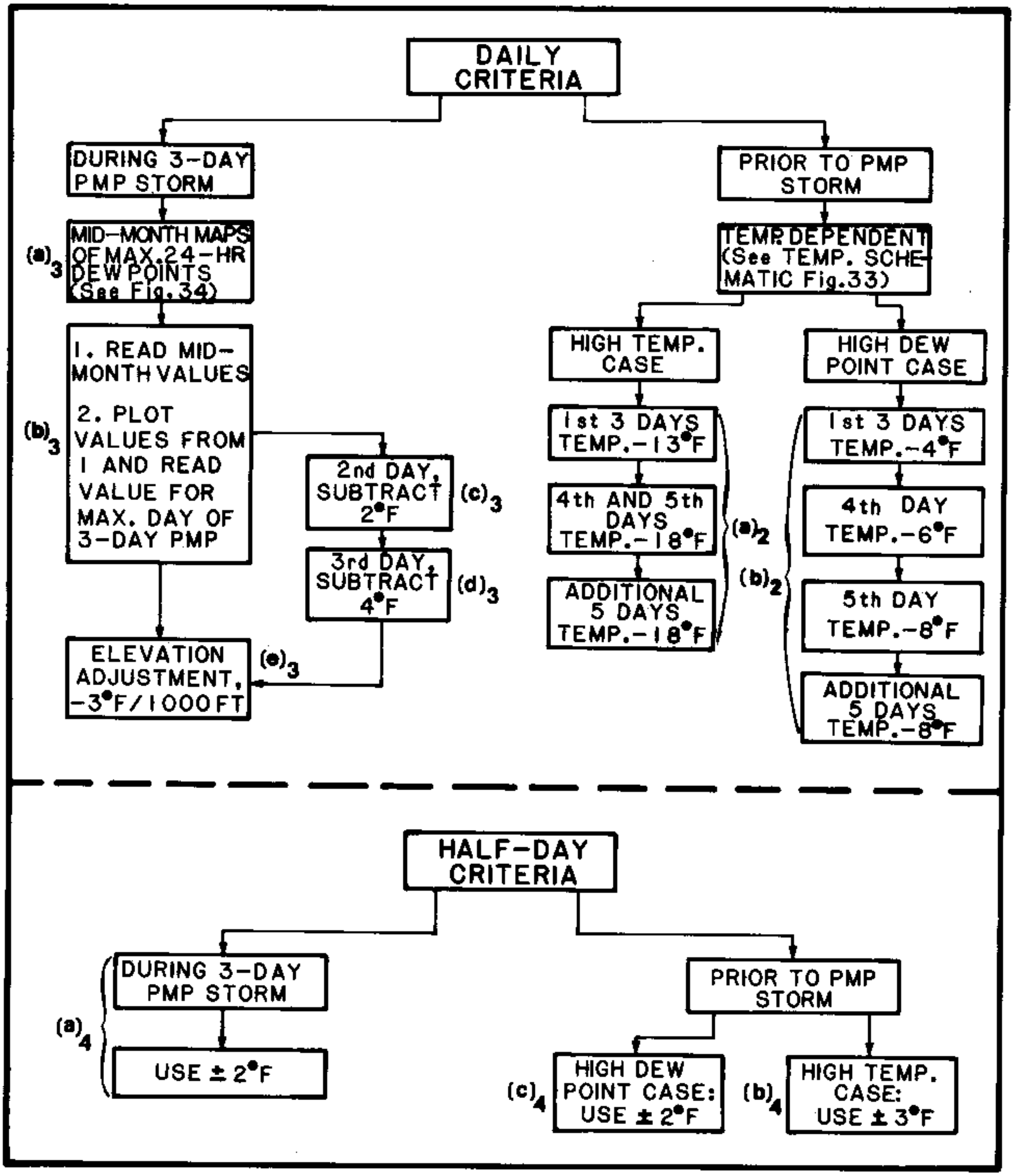


Figure 35.—Schematic for snowmelt dew-point criteria.

3. Prior to the 3-day PMP event with high-dew-point case, use $\pm 2^\circ F$ ($1.1^\circ C$).

4.3.7 Schematic of Snowmelt Dew-Point Criteria

A schematic in condensed form giving all the basic snowmelt dew-point criteria just discussed, is shown in figure 35. This schematic, in conjunction with the schematic of figure 33 and other required figures, constitutes a stepwise procedure for obtaining the necessary dew-point criteria for snowmelt.

4.4 Wind Criteria

Wind criteria, in addition to being necessary for snowmelt computations during the 3-day PMP, are also needed for prior-to-PMP snowmelt for the two types of prevailing temperature regimes (high-temperature and high-dew-point) that are possible prior to the 3-day PMP. Seasonal variation and elevation factors are also needed and developed for the wind criteria.

4.4.1 Wind Criteria During the 3-Day Probable Maximum Precipitation

Wind criteria during a 3-day PMP storm have evolved for use in southeast Alaskan basins from specific Alaskan basin studies over a period of years. An extensive summary of winds aloft, including barrier effects, was done in connection with the PMP estimate for Bradley Lake, Alaska (U.S. Weather Bureau 1961). From data used in this estimate, which included wind data from southeast Alaska and additional work involving seasonal variation for winds from southeast Alaska to the northwest coast of the United States, we adopt April daily sea-level wind criteria for the study area for the 3-day PMP of 36, 28, and 25 mph (16.1, 12.5, and 11.2 m/s), respectively. These values have been reduced 25 percent from the originally higher free-air wind values to allow for surface effects. This 25-percent reduction includes allowance for occurrence over snow cover, in addition to an adopted slight reduction for generalizing southward along the coast, thereby providing a consistent trend to tie into the lower magnitude PMP winds used in the Northwest PMP Report (U.S. Weather Bureau, 1966).

4.4.1.1 Seasonal Variation Factors. Seasonal variation factors with April set equal to 100 percent were adopted from generalizations of surface and upper-air wind surveys for south and southeast Alaska points used in earlier PMP computations (U.S. Weather Bureau 1961). With April winds equal to 100 percent, May is 92 percent, while both June and July (where data indicated insignificant differences) are 83 percent.

4.4.1.2 Barrier Adjustments. The complicated terrain features in southeast Alaska have unusual effects upon the wind. We cannot hope to unravel for generalizing purposes the detailed, complicated nature of such effects. However, on a generalized basis, we know that as multiplication of barriers increase inland, an overall average decrease of the wind must take place in low levels. Some clues to these "sheltering effects" for a particular south coast area (i.e., Bradley Lake) were developed in an earlier PMP study (U.S. Weather Bureau 1961). For southeast Alaska we generalize by adopting a modest reduction in wind of 5 percent per 1,000-foot barrier. The method of obtaining the barrier involves a compensating factor in application to snowmelt computations in that maxima rather than mean elevations are used along a particular inflow direction.

The generalized elevation chart (fig. 5) is the basic chart for barrier determination for adjusting the "no-barrier" sea-level winds. We intend to provide reasonable overall barrier estimates for basins in southeast Alaska where very complicated terrain separated by bodies of water is characteristic. To obtain the barrier for a specific basin, the following steps are required:

1. Draw straight lines from the center of a basin to the coast beginning at 256° and continuing with additional lines at 27° angular increments counterclockwise to 148° (256°, 229°, 202°, 175°, and 148°). This provides line segments (each representing a 27° sector) so that the directions of the inflow (from regions of warmer waters) from 270° (west) counterclockwise to 135° (southeast) are sampled.

2. Determine the maximum generalized elevation each segment passes across from the basin to the coast for each segment in step 1 that reaches water (only segments that reach water represent a moisture inflow direction). Ignore segments that do not reach water.

3. Determine a mean of values of barrier height along each applicable segment (i.e., toward a moisture source) in 2. This computed mean is the barrier to that basin. An adjustment of -5 percent per 1,000 ft (305 m) is applied to the no-barrier winds, based upon the computed barrier height. This adjustment applies to all elevations.

4.4.1.3 Elevation Variation of Wind During Probable Maximum Precipitation. The adopted variation of wind with height during the 3-day PMP is shown in table 19 and also on the schematic for snowmelt wind criteria (fig. 36). If the user needs winds for elevations higher than 7,000 ft (2,134 m), the trend of 10-mph (4.5-m/s) increase per 1,000 ft (305 m) may be continued.

Table 19.—Elevation adjustments for wind during and period prior to probable maximum precipitation for high-dew point case

Elevation Ft.	Elevation m	Wind (% 1,000-mb wind)
1,000	305	107
1,500	457	118
2,000	610	141
3,000	914	195
4,000	1,220	215
5,000	1,524	225
6,000	1,829	235
7,000	2,134	245

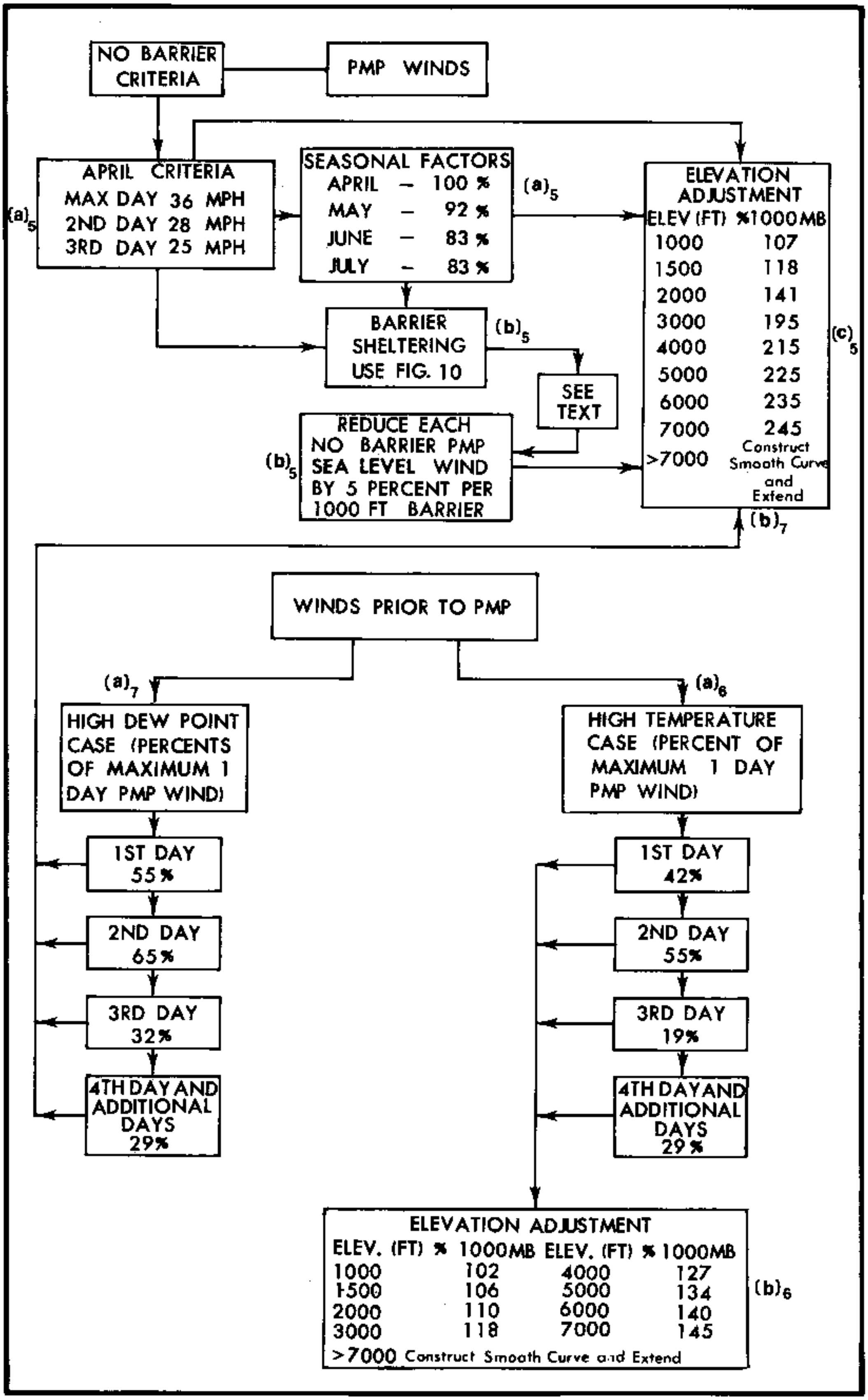


Figure 36.—Schematic for snowmelt wind criteria.

Some of the support for the elevation variation of wind primarily stems from generalizations employed in the Bradley Creek estimate (U.S. Weather Bureau 1961) which was based partly upon more extensive work done in generalized estimates along the west coast of the United States (U.S. Weather Bureau 1961, 1966b). High-dew-point situations in southeast Alaska support a large increase in wind with height above the lowest layers.

Because of the nature of the terrain in southeast Alaska, together with a pronounced overall stabilizing effect of the cold waters on the low-level winds, we concluded that the most pronounced increases in winds should take place somewhat above the surface layers. This is unlike the variations for both the coast range and the Sierras of California where sharp increases of wind with elevations in the low levels are more realistic. (This is due to extensive mountain chains providing a greater disturbance and mixing of air).

4.4.2 Winds Prior to Probable Maximum Precipitation

Sequences of winds were generalized for periods prior to the 3-day PMP for both high-dew-point and high-temperature situations. The main differences between high-temperature and high-dew-point cases are for the first 3 days prior to the first day of the PMP. For durations beyond this number of days (that is, 3 days of PMP and 3 prior days) differences between these two situations must diminish or, if very long sequences are required, probably reverse, since maximum sustained (or average) winds for long durations such as a month exert some definite limitations on the sequences of duration that are of many days' duration.

4.4.2.1 Winds Prior to Probable Maximum Precipitation - High-Dew-Point Case. For wind criteria prior to PMP in the high-dew-point case, winds as percentages of maximum 1-day PMP wind are 55, 65, and 32 percent, respectively for 1, 2, and 3 days prior to the first day of the 3-day PMP. For the fourth day prior and for additional days prior to 4 days, 29 percent is to be used. These wind criteria are shown schematically on figure 36. These adopted percentages, combined with the wind for the 3 days of PMP, would give a 6-day average surface wind of about 26 mph (11.6 m/s). As a basis for judging the reasonableness of this 6-day average, the highest Juneau wind for 5 consecutive days was 18.5 mph (8.3 m/s) on May 4-8, 1958. Annette's highest 5-day wind was 21.4 mph (9.6 m/s).

Our 6 days of wind criteria with the suggested 29 percent (for the high-dew-point case for additional days prior to the 3-day PMP (fig. 36) would result in a month of maximum wind (not reduced for over-snow occurrences) of about 17 mph (7.6 m/s). This is approximately twice the mean April wind for Juneau. For Juneau the highest observed average monthly wind for May was equal to 1.4 times the mean, or 11.2 mph (5.0 m/s) in May 1955. Other data support the idea that a monthly average wind of about one and one-half times the mean is a rather extreme wind for such a duration. This, then, offers constraints on winds of duration shorter than a month but longer than a few days. Thus, for the windier high-dew-point case, it appears our wind criteria are amply severe for durations beyond that of the 3-day PMP.

The adopted wind criteria, based much on prior Alaskan work (e.g., U.S. Weather Bureau, 1966a) gives a wind ratio between monthly and 5-day values of 0.61. This ratio is the same as one derived from Juneau's maximum winds, a 11.2 mph (5.0 m/s) wind for the month and a 18.4 mph (8.2 m/s) wind for 5 days.

The elevation variation of wind in the high-dew-point prior-to-PMP case is the same as that for the 3-day PMP winds (table 19).

4.4.2.2 Winds Prior to Probable Maximum Precipitation - High-Temperature Case. For wind criteria prior to PMP for the high-temperature case, the adopted winds as percentages of the maximum 1-day PMP wind are 42, 55, and 19 percent, respectively for 1, 2, and 3 days prior to the first day of the 3-day period. These criteria are less than those adopted for the high dew point prior to the PMP case. For the fourth day prior to the PMP and for additional earlier days, 29 percent is to be used. These wind criteria are also shown schematically on figure 36.

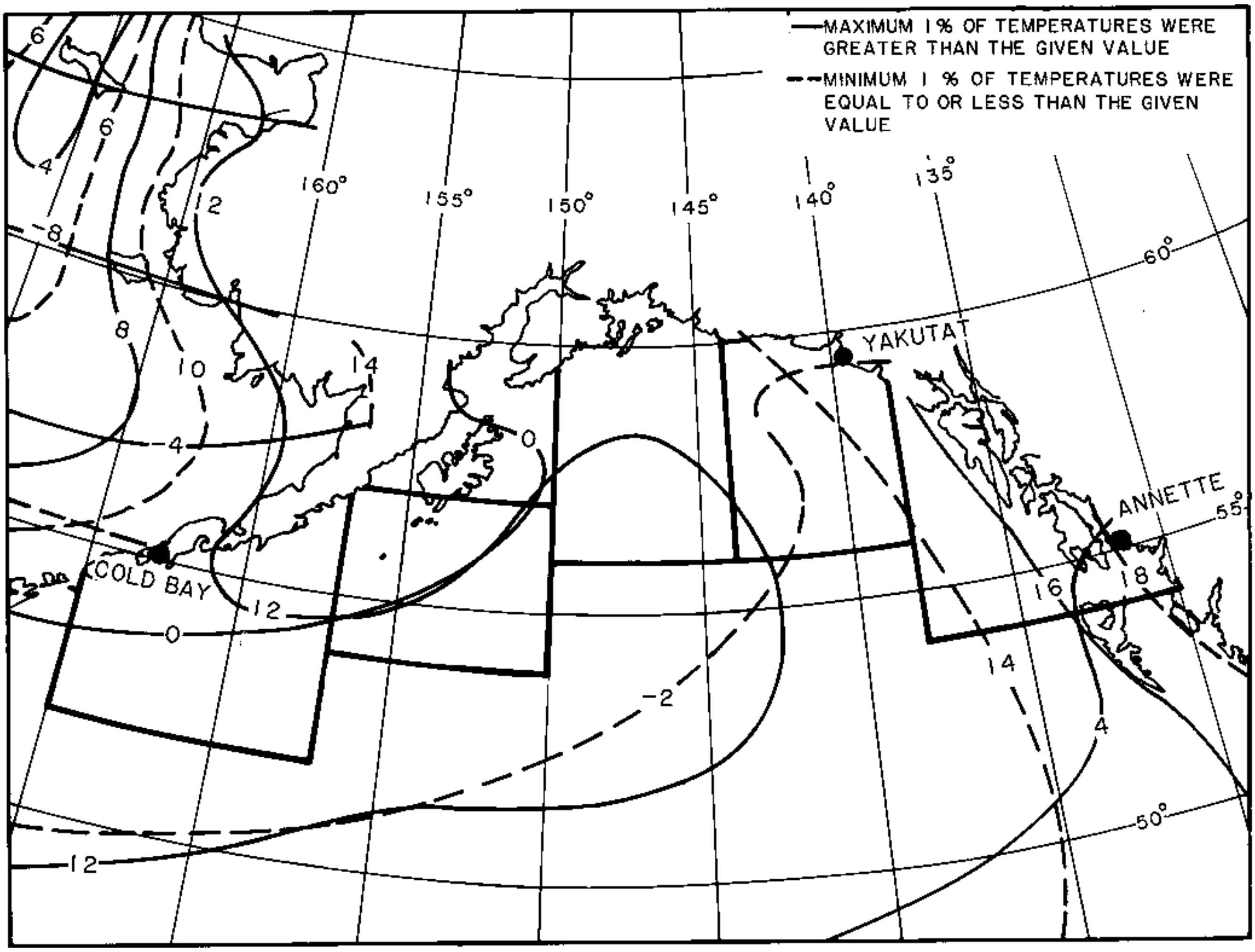
4.4.2.3 Elevation Variation of Winds in High-Temperature Case. The variation of wind with height for the high-temperature case is shown in table 20. This table was developed from the prior studies for specific Alaskan basins.

Table 20.--Elevation adjustments for wind for high-temperature case prior to probable maximum precipitation

Elevation ft.	(m)	Wind (% of 1,000-mb wind)
1,000	305	102
1,500	457	106
2,000	610	110
3,000	914	118
4,000	1220	127
5,000	1524	134
6,000	1829	140
7,000	2134	145
>7,000	construct smooth curve and extend.	

4.5 Support for Adopted Wind and Temperature Criteria

In a recent climatic atlas for Alaska (Brower et al. 1977), a comparison of a considerable amount of summarized data supports the similarity of climate between the south coast and southeast Alaska. Also, supported in this Atlas are the various combinations of data used in the generalized snowmelt portion of this report. One important example of the latter is the dual combination of light winds with the high-temperature prior-to-PMP melt sequence and the stronger winds with the lower-temperature (but higher dew-point) sequence. These dual melt criteria and the similarity of these criteria for the south coast and southeast Alaska are both supported by the climatic data. Figure 37, taken from Brower's work, shows for May as an example, the similarity for areas C, D, and E (South Coast) with F (southeast Alaska). The stronger winds are associated with the "moderate" (neither high nor low extremes) marine climate temperatures. High temperatures can be seen to be associated with light winds from the same figure. This is consistent with the synoptic conclusions on high insolation melt situations common to the south coast and southeast Alaska, as well as th interior.



Marine Area C

TEMP (°C)	WIND SPEED (KTS) 0-3	4-10	11-21	22-33	≥ 34
16.17	0	+	+	0	0
14.15	1	1	+	0	0
12.13	1	2	1	0	0
10.11	3	4	2	+	0
8.9	4	10	5	1	+
6.7	5	11	13	3	+
4.5	2	8	9	3	1
2.3	2	2	3	2	1
0.1	+	+	+	+	+
-2.-1	+	0	+	+	+
-4.-3	0	0	0	0	+
					1171

Marine Area D

TEMP (°C)	WIND SPEED (KTS) 0-3	4-10	11-21	22-33	≥ 34
16.17	+	+	+	0	0
14.15	+	+	+	0	0
12.13	1	1	+	+	0
10.11	2	4	2	+	0
8.9	3	8	7	1	+
6.7	5	14	16	4	1
4.5	1	8	10	4	1
2.3	+	2	2	1	1
0.1	0	+	+	+	+
-2.-1	0	+	0	0	+
-4.-3	0	0	0	0	0
					1943

Marine Area E

TEMP (°C)	WIND SPEED (KTS) 0-3	4-10	11-21	22-33	≥ 34
16.17	+	+	+	0	0
14.15	+	1	+	0	0
12.13	+	2	1	0	0
10.11	2	4	3	+	0
8.9	4	10	10	2	+
6.7	3	15	15	5	1
4.5	1	6	7	2	1
2.3	+	2	2	+	+
0.1	0	0	+	+	+
-2.-1	0	+	0	0	0
-4.-3	0	0	0	0	0
					1110

Marine Area F

TEMP (°C)	WIND SPEED (KTS) 0-3	4-10	11-21	22-33	≥ 34
20.21	0	+	0	0	0
18.19	+	+	+	0	0
16.17	+	1	1	0	0
14.15	+	2	+	0	0
12.13	1	5	2	+	0
10.11	3	11	5	1	+
8.9	4	15	12	3	1
6.7	2	9	11	4	+
4.5	1	2	2	+	+
2.3	+	+	+	+	0
0.1	0	0	0	0	0
					1454

5 Air temperature extremes (°C) **May**

Figure 37.—Relation of wind to temperature for differing marine areas (from Brower et al. 1977).

4.6 Stepwise Procedure for Snowmelt Criteria (Other Than Snowpack)

We shall now briefly give the steps for obtaining snowmelt by the application of criteria that are shown schematically in figures 33 (temperature), 35 (dew point), and 36 (wind). The steps in sections 4.6.1 through 4.6.7 are identified on the appropriate figures with subscripts relating to the lettered step and numbered section, e.g., $(b)_1$ indicates step b. in section 4.6.1.

4.6.1 Steps for Obtaining Temperatures Prior to Probable Maximum Precipitation.

The schematic of figure 33 shows an outline of this sequence of steps.

a. Read sufficient midmonth values of mean monthly 1000-mb temperatures (fig. 31) at the center of the basin to construct a smooth temperature-time relation for interpolation of first day prior to the 3-day PMP event.

b. Apply the departures for high-temperature case shown $(b)_1$ in figure 33 to the value from step $(a)_1$. If any temperature higher than 62°F (16.7°C) results, use 62°F (16.7°C) for such cases.

c. Apply the departures for high-dew-point case shown $(c)_1$ in figure 33 to the value from step $(a)_1$.

d. Obtain elevation-adjusted values by subtracting 4°F/1,000 ft (2.2°C/305 m) for the high-temperature case $(d)_1$ (temp) and 3°F/1,000 ft (1.7°C/305 m) for the high-dew-point case $(d)_1$ (d.p.), respectively, to the low-level values obtained in steps $(b)_1$ and $(c)_1$.

4.6.2 Steps for Obtaining Dew Points Prior to Probable Maximum Precipitation

The schematic of figure 35 shows an outline of the sequence of these steps.

a. For the high-temperature case, apply the adjustment shown $(a)_2$ under high-temperature case (fig. 35) to the values obtained in steps $(b)_1$, or $(d)_1$ (temp.). Application to step $(d)_1$ (temp.) values allows for the -4°/1,000 ft (-2.2°C/305 m) elevation adjustment, and an additional adjustment for elevation should not be applied.

b. For the high-dew-point case, apply adjustments shown $(b)_2$ in figure 35 for the high-dew-point case to the values obtained in steps $(c)_1$, or $(d)_1$ (d.p.). For example, for the fourth day prior to the first day of the 3-day PMP event in the high-dew-point case, the dew point is 6°F (3.3°C) less than the temperature for the fourth day prior to first day of the 3-day PMP event. Again, as in step $(a)_2$ of this section, the use of step (d) (d.p.) values allow for the appropriate elevation variations, which in the high-dew-point case is -3°F/1,000 ft. (-1.7°/305 m), and an additional adjustment should not be applied.

4.6.3 Steps for Daily Dew Points and Daily Temperatures During Probable Maximum Precipitation

Since temperatures during the 3-day PMP event are the same as the dew points, the sequence of 24-hr dew points are determined (fig. 35). The half-day temperature and dew-point problem is covered under section 4.6.4.

a. To get daily dewpoints (and, also temperatures) during the 3-day PMP event, midmonth daily maximum dew points are read from the center of the basin in appropriate maps in figure 34.

b. From midmonth maximum values from step $(a)_3$, plot and obtain from a smooth curve connecting the values the appropriate maximum 1-day dew point (and also therefore temperature) for maximum day of the 3-day PMP event.

c. For second highest day of the 3-day PMP event, subtract 2°F (1.1°C) from value in step $(b)_3$.

d. For the third highest day of the 3-day PMP event, subtract 4°F (2.2°C) from value in step $(b)_3$.

e. For elevation variation, apply -3°F/1,000 ft (-1.7°C/305 m) to the values in steps $(b)_3$, $(c)_3$, and $(d)_3$.

4.6.4 Steps for Obtaining Half-Day Dew-Point and Temperature Values.

The schematic illustrating the steps for obtaining half-day dew-point values is the lower half of figure 33 while that for half-day temperature values is shown on the lower part of figure 35.

For basins not located at sea level, required elevation adjustments should be completed prior to proceeding to the steps for obtaining half-day values.

a. For half-day dew-point and temperature values during the 3-day PMP event, apply ± 2°F (±1.1°C), $(a)_4$, to the values obtained in steps $(b)_3$ through (d_3) or (e_3) as appropriate (fig. 35).

b. For prior to the 3-day PMP event half-day dew-point criteria for the high-temperature case, apply ± 3°F (± 1.7°C), $(b)_4$ to the appropriate values from step $(a)_2$.

c. For prior to the 3-day PMP event half-day dew-point criteria for the high-dew-point case, apply ± 2°F (± 1.1°C), $(c)_4$, to the appropriate values obtained in step $(b)_2$.

d. For half-day temperatures prior to the 3-day PMP event, for the high-temperature case, apply ± 9°F (± 5.0°C), $(d)_4$, to the values obtained in steps $(b)_1$ or $(d)_1$ (temp.), as appropriate.

e. For half-day temperatures prior to the 3-day PMP event for the high-dew-point case, apply ± 6°F (± 3.3°C), $(e)_4$, to the values obtained in steps $(c)_1$ or $(d)_1$ (d.p.), as appropriate.

4.6.5 Steps for Obtaining Winds During Probable Maximum Precipitation

Figure 36 is the schematic showing wind criteria.

a. The 3 days of April sea-level wind of 36, 28, and 25 mph (16.1, 12.5, and 11.2 m/s) are multiplied by appropriate percent (mid-April = 100 %) to obtain the 3 days of wind for the chosen date of PMP placement (fig. 36). The percents shown in figure 36 are midmonth values, and values for intermediate dates should be interpolated as necessary.

b. To determine the barrier influencing a basin, lines are drawn from the center of the basin toward 256°, 229°, 202°, 175°, and 148°. The maximum barrier from figure 5 along each of these lines <u>that reaches a moisture source</u> is tabulated and the average of these determined. The barrier reduction to winds is then determined as the product of the average of the elevations in thousands of feet times 5 percent. The surface winds from step $(a)_5$ are reduced by this percentage.

c. To adjust the barrier adjusted sea-level winds for elevation to provide a wind profile, the elevation adjustment is applied to the winds of step $(b)_5$. The percentage adjustments are determined from the elevation adjustment box, $(c)_5$, in figure 36. For example, for 2,000 ft (610 m) the values from step $(b)_5$ are multiplied by 1.41.

4.6.6 Steps for Obtaining Winds Prior to the 3-Day Probable Maximum Precipitation - High-Temperature Case

The lower right-hand side of figure 36 shows a schematic of the steps required to develop winds prior to the PMP storm for the high-temperature case. These steps are:

a. For the high-temperature wind sequence, the maximum barrier-adjusted 1-day sea-level wind from step $(b)_5$ is multiplied by the percents shown in the boxes on the lower right side of figure 36. Thus, for a wind sequence leading up to the PMP these percentages are: 29, 29, 29, 19, 55, and 42.

b. The elevation variation for the high-temperature case winds from step $(a)_6$ comes from application of the percentages in the elevation adjustment box near the bottom of figure 36. For example, for 2,000 ft (610 m), the winds from step $(a)_6$ are multiplied by 1.10, or for 6,000 ft (1,829 m) by 1.40.

4.6.7 Steps for Obtaining Winds Prior to the 3-Day Probable Maximum Precipitation — High-Dew-Point Case

The lower left-hand side of figure 36 shows the schematic of the steps required to develop winds prior to the PMP storm for the high-dew-point case. These steps are:

a. For the high dew-point wind sequence, the maximum barrier adjusted 1-day wind from step $(b)_5$ is multiplied by the percents shown in the boxes at the lower left side of figure 36. Thus, for a wind sequence leading up to the 3-day PMP event, these percentages are 29, 29, 29, 32, 65, and 55.

b. The elevation variation for the high-dew-point case winds from step $(a)_7$ comes from application of the percentages in the elevation adjustment box in the upper right corner of figure 36. (This is the same elevation used for winds during the 3-day PMP storm, step $(c)_5$.) For example, for 2,000 ft (610 m) the winds from step $(a)_7$ are multiplied by 1.41, or for 6,000 ft (1,829 m) by 2.35.

4.7 Snowpack Criteria

4.7.1 Introduction

The development of generalized snowpack criteria involved (a), the integration of a variety of data including snow-related data that went into the development of the MAP chart (chapter 2), (b) the use of certain guiding principles related to geographical and weather-related controls of snow accumulation and retention, and (c), preliminary computations at a variety of locations and subsequent development of appropriate charts to synthesize overall consistency. The resulting procedure allows for regional, elevation, and seasonal variations. The charts and stepwise procedure thus allows the user to obtain, for a particular basin, snowpack and subsequent critical melt for a variety of placement dates of PMP.

4.7.1.1 Working Hypotheses. Other things being equal, snowpack must increase inland (for given elevations of comparable exposure, etc.) due to a temperature-dependent factor. Over our study area, temperatures decrease inland, generally from southwest-to-northeast, resulting in increased snowpack (for the same MAP, for example) since more of the precipitation within storms falls in the form of snow, and the season for snow begins sooner and ends later as one moves away from the coast. We need to keep in mind, that here we are referring to a temperature factor (or gradient) related to distance away from the warmer coastal areas.

Temperature reduction, as related to elevation, is a separate matter. The elevation-dependent temperature factor is dealt with later by a tie-in of snowpack with regional variations of MAP.

Since our snowpack procedure relates strongly to MAP, we need to clarify certain principles related to our use of the MAP for the study area to estimate snowpack. The underlying principles of interpretation and use are:

a. A large quantity of data, including snow-related data, went into the MAP chart.

b. For snowpack purposes, one possibility considered was the use of a MAP index which would maximize snowpack (implicitly at all elevations) by using a certain ratio (e.g., 125 percent) of MAP to represent an unusual year.

c. Since overly excessive snowpacks (i.e., more than could melt in a season) result at the higher elevations from application of b., we chose to use the unadjusted MAP chart in a manner which accomplishes the desired aim of maximizing snowpack (compared to normal) at the lower elevations, especially where smaller snowpacks typically exist that can be melted in a hydrologically critical period.

4.7.2 Background Data

A variety of information is available which provides perspective on the magnitude of snowpack that could be present prior to the PMP. Some of these data can only be used indirectly.

4.7.2.1 Snow-Course Data. Some snow-course data were available within the study region. These data were limited in length of record and did not sample the entire range of elevations and exposures in southeast Alaska. The maximum observed values (table 21) at these locations do, however, provide a lower limit to an extreme snowpack compatible with the PMP.

Table 21.—Maximum observed and mean snowpack water-equivalent values for selected snowcourses in southeast Alaska

	Elevation		Maximum observed		Mean	
Name	ft	m	in.	mm	in.	mm
Crater Lake	1,750	533	87.5	2,222	70	1,778
Speel River	280	85	52.0	1,320	35	889
Long Lake	1,080	329	59.0	1,499	46	1,168
Douglas Ski Bowl	1,640	500	42.0	1,067	38	965
Range in mean snowpack values for snow courses near Ketchikan for two elevations	660	201	-	-	27-34	686-864
	2,000	607	-	-	66-71	1676-1803

4.7.2.2 Station Data. One approach for determining maximum snowpack is the use of a "synthetic season." This approach played an important role in Yukon estimates (U.S. Weather Bureau, 1966a). In this method, the maximum observed snowpack value for each month for a station is combined without regard to the year of occurrence. This synthetic season approach was also used in this study for southeast Alaska as an aid in defining snowpack. For example, the synthetic season snowpack water equivalents for two widely separated stations, Juneau and Tree Point Light Station, were 17 in. (432 mm) and 65 in. (1651 mm), respectively. Each station had a MAP of approximately 100 in. (2540 mm). The synthetic season approach was used for all useful data in southeast Alaska with initial values "normalized" to remove orographic effects with initial "shaping" determined by two reasonable hypotheses (sec. 4.7.1).

Statistical estimates of water equivalent amounts provide another approach useful where reasonable lengths of record are available. Such estimates of snowpack water equivalents were made from seasonal maximum data at Juneau and Annette using the Fisher-Tippett type I distribution. These gave estimated 1 percent frequency values of about 11.5 in. (292 mm) for Juneau and about 6 in. (152 mm) for Annette.

4.7.2.3 Snowmelt Computations. A method was developed, chapter 2, for estimating snowmelt from monthly and seasonal streamflow data with adjustments for concurrent precipitation. The 1963-64 season was quite unusual for snow cover and the subsequent snowmelt. The estimated snowmelt (taking note that the contributing portion of the basin differs as melt progresses) for five basins (fig. 5 for locations) in 1964 were:

1. Perserverance Creek, 28 in. (711 mm).

2. Fish Creek near Ketchikan, 34 in. (864 mm).

3. Manzanita Creek, 42 in. (1067 mm).

4. Winstanley Creek, 34 in. (864 mm).

5. Baranof River, 71 in. (1803 mm).

4.7.2.4 Previous Snowpack Estimates. A prior detailed estimate for Long Lake Drainage resulted in estimated values of snowpack (water equivalent) from 50 in. (1270 mm) at 814 ft (248 m) to 90 in. (2286 mm) at 3,500 ft (1,067 m) for April 15. This study also provided important input to the present study.

4.7.3 Procedure for Snowpack Determination

The total snowpack for this region was determined through a series of steps. These steps then form the basis for the stepwise procedure the user follows to determine maximum snowpack for individual basins. The first approximation is based on the MAP. This is adjusted for the percent of MAP that occurs as rain (i.e., length of accumulation season) and the amount of snow that melts between the end of the snow accumulation season and the beginning of snowmelt computations for the PMP. In addition, the first approximation snowpack is also adjusted geographically for factors not handled in determining the first approximation snowpack.

4.7.3.1 First Approximation to Snowpack. The generalized MAP of figure 4 provides the basis for determining a first approximation to the accumulated snowpack for individual basins. Where the MAP is less than 150 in. (3810 mm), an average value for the basin can be used as the first approximation. For basins where the average MAP is 150 in. (3810 mm) or greater, an average value should not be used as our first approximation. For these basins, it is desirable to indicate the distribution of MAP through the elevations range of the basin rather than use a single average value throughout the basin. Allowing a uniform distribution of MAP for these basins with MAP larger than 150 in. (3810 mm) would be equivalent to stretching the distribution of MAP to unrealistic proportions. The procedure, therefore, must not permit unrealistically large snowpack accumulations. We have adopted the scheme of using two-thirds of the basin average MAP at the lowest elevation and four-thirds of the basin average MAP at the highest elevation of the basin. The variation between these two extremes is linear. This is shown schematically in figure 38 for an average basin MAP of 150 in. (3810 mm) for three basins. In each case the lowest elevation is sea-level with the highest elevation varying by 1,000-ft increments.

4.7.3.2 Adjustment for Length of Snow Accumulation Season. Only a portion of the MAP in southeast Alaska occurs as snow. The first adjustment to the estimated snowpack water equivalent is to make allowances for the longer snow accumulation season at higher elevations compared to the lower elevations where mean temperatures are higher. In addition, we need to allow for melt, if any, between the end of the snow accumulation season and the date selected for the PMP event.

Figure 39 was developed from accumulation and melt season variations with elevation used as input to the MAP chart. For maximizing of snowmelt, some additional conservativeness was built into the curve labeled "curve for beginning melt" (fig. 39) by use of a delay of 15 days from the mean melt date for each elevation. This increases the snow accumulation season, the sloping elevation lines on figure 39. Thus, the percents of MAP in this chart (ordinate) reflect this 15-day extension. Additionally, figure 39 provides the user with the number of days of melt for each elevation that he must allow for based upon the date selected for the PMP event. For example, if the PMP event were to begin May 15, then figure 39 (proceed vertically from the May 15 mark to say the 1,000-ft (305-m) elevation) shows that prior snowmelt would have to begin more than a month prior to May 15. In actual computations, the required melt for reducing snowpack water equivalent (in inches) is given directly in figure 40 for any desired beginning date for the placement of the 3-day PMP event (hereafter referred to as the placement date).

4.7.3.3 Melt Between End of Snow Accumulation Season and Probable Maximum Precipitation. For some basins, the range of elevations is large. For these basins figure 40 is needed to determine the amount of melt that must be assumed for reducing the snowpack water equivalent. This figure was derived from mean melt data used in chapter 2 as an aid in determining MAP from snow course date, etc. Figure 40 provides (for a given elevation) the estimated amount of melt for the period covered by a horizontal elevation line from the "melt begin" dashed curve of figure 39 to its intersection with a vertical line for the placement date (i.e., abscissa of figure 39). Discussion of these increasing

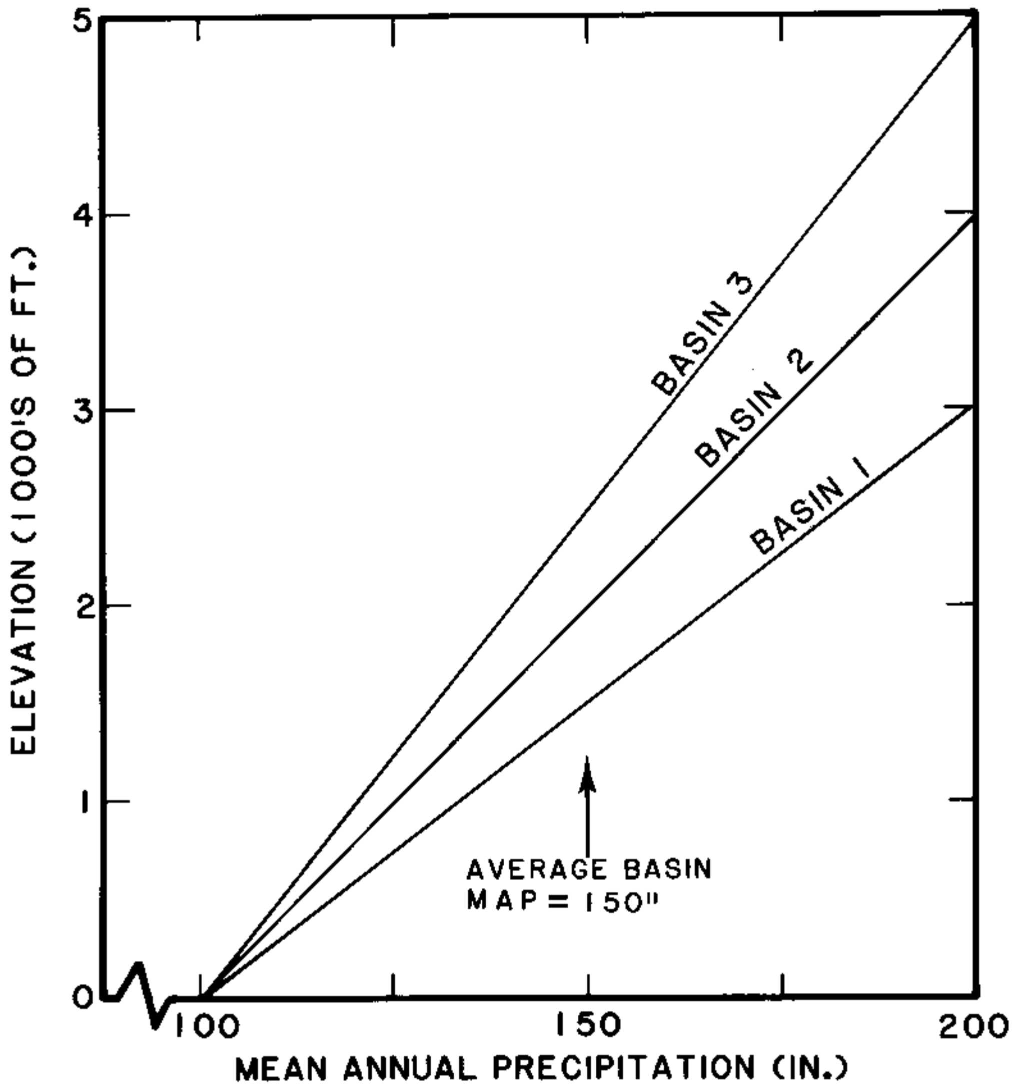


Figure 38.—Schematic for illustrating how mean annual precipitation variation can be determined for use in snowpack accumulations when mean annual precipitation $\geq$ 150 in. (3810 mm).

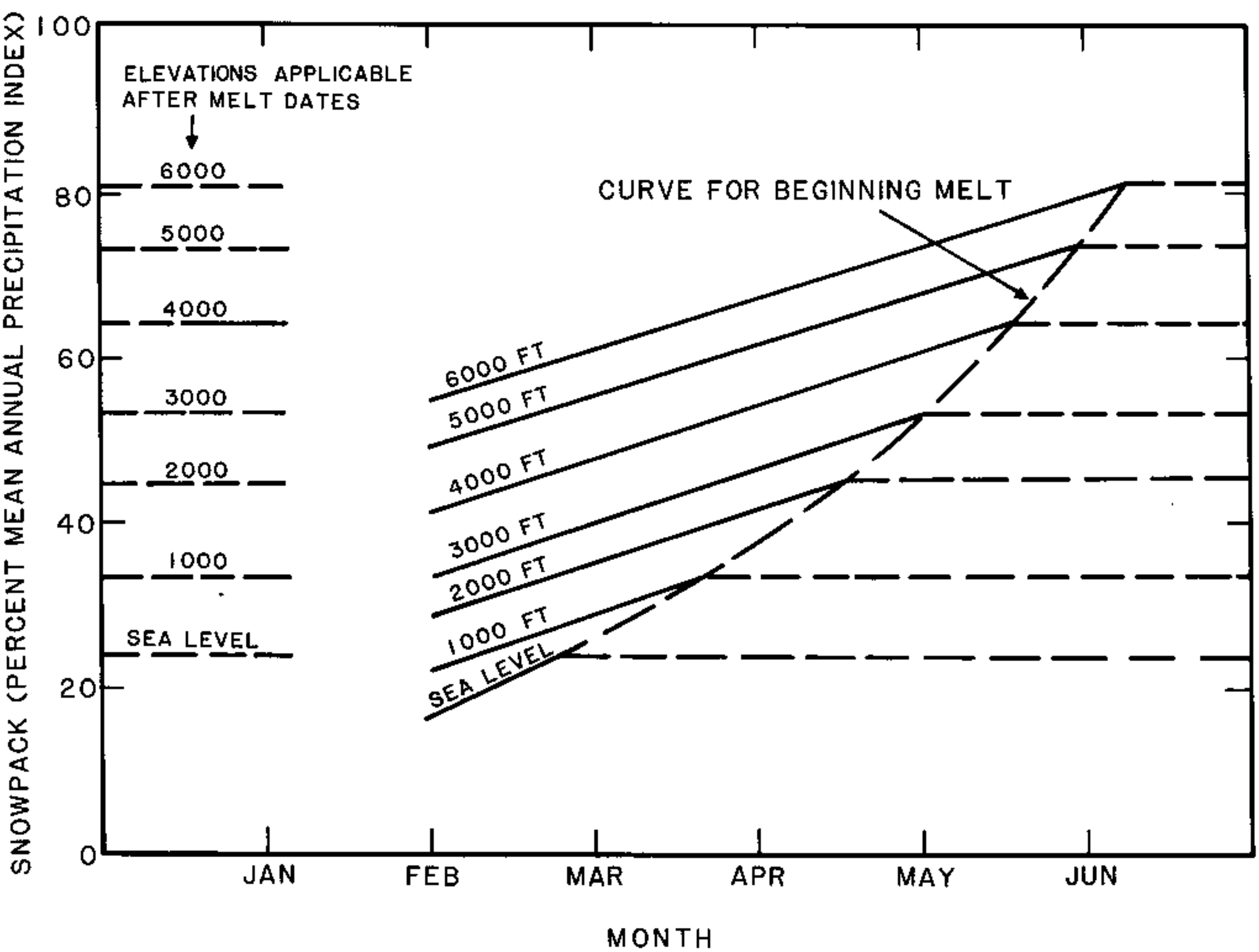


Figure 39.--Snowpack related to month and elevation as percent of mean annual precipitation.

melt rates with season was covered in chapter 2. The water equivalent melt (abscissa of fig. 40) results from multiplying days during the melt period from figure 39 by the adopted mean melt rates of chapter 2.

4.7.3.4 Geographic Variation. The snow accumulation season varies across southeast Alaska as a function of distance from the relatively warmer waters of the Pacific. The 100-percent curve (fig. 41) represents basic values of snowpack from application of appropriate percents for basin elevations to MAP values from figure 6. The placement of the 100 percent curve on this figure is empirically determined as is the spacing for lower and higher percentages. The magnitude and shaping of the lines of figure 41 comes from a compositing of all pertinent clues from various types of data and studies discussed in section 4.7.2 and from basic principles discussed in section 4.7.1. For a given MAP and elevation, the net result is to allow for greater snow accumulation (snowpack) inland and away from the warmer maritime influences.

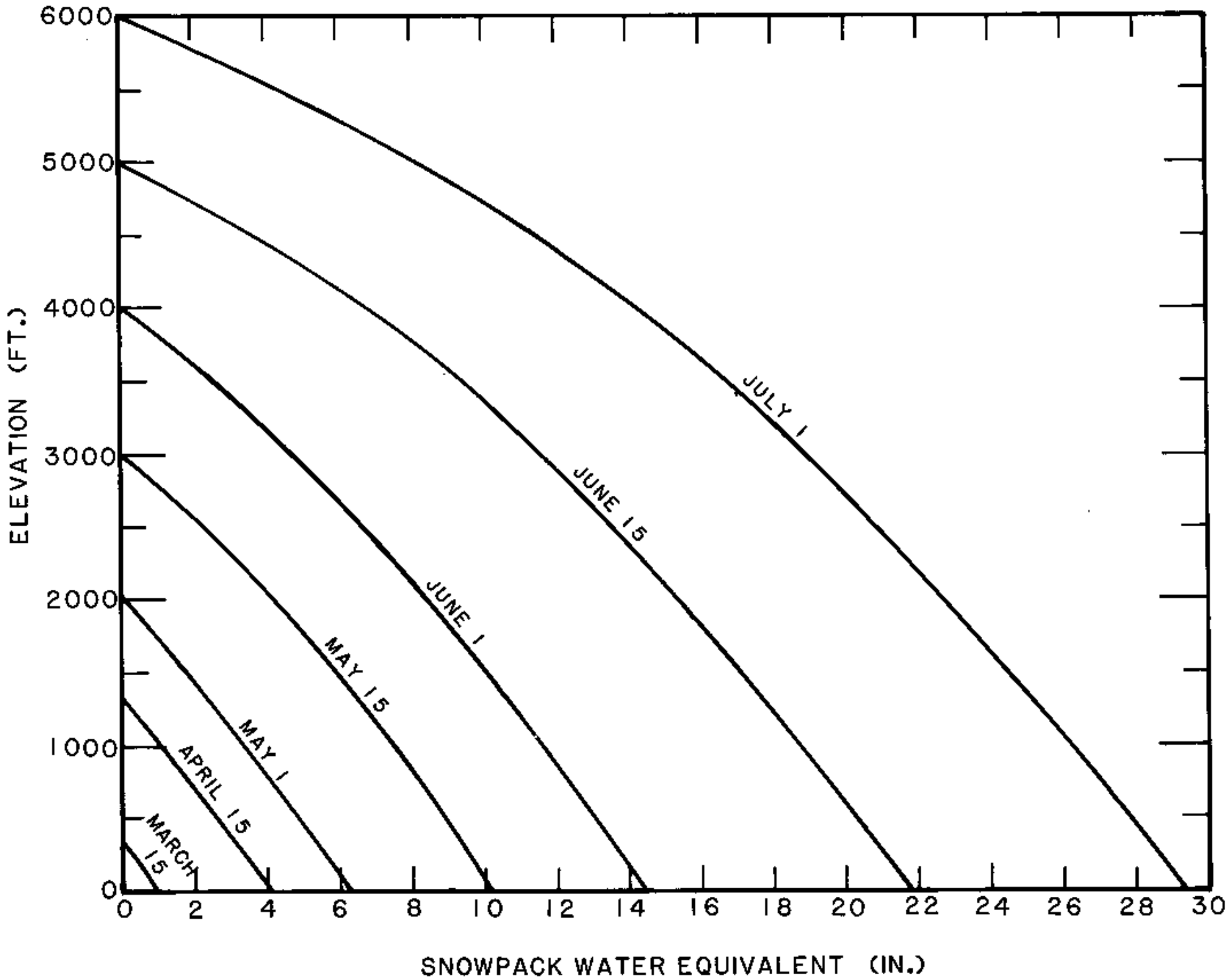


Figure 40.—Required melt for period of time up to probable maximum precipitation.

4.7.4 Stepwise Procedure for Snowpack (Water Equivalent) Determination

Figure 42 is a schematic that shows the steps to determine the appropriate snowpack water equivalent for use with PMP. These steps are:

a. Outline basin on 1:1,000,000 or other suitable base map.

b. Determine from an appropriate topographic chart the mean elevation for the basin, if not already available.

c. Superimpose basin on figure 6 (MAP) and determine MAP for the basin. If the basin MAP is less than 150 in. (3810 mm), use MAP value uniformly throughout the basin. If the basin MAP is $\geq$ 150 in. (3810 mm), use two-thirds MAP at lowest elevation and four-thirds MAP at highest elevation assuming a linear variation between the values at the lowest and highest elevation.

d. Select a placement date for the 3-day PMP event.

e. Using date selected in d., locate this melt date on figure 39 and move vertically to appropriate horizontally extended elevation line(s) and read from vertical scale (coordinate in percent) the appropriate percent(s) of MAP.

f. Multiply the MAP value(s) from step c. by the appropriate "same elevation" percent(s) from step e. to obtain first approximation snowpack value(s) for the basin.

g. The first-approximation snowpack value(s) from step f. may need to be adjusted depending upon the basin location in relation to the ratio curves of figure 41. If the basin is on the curve labelled 1.0, no regional adjustment is required. Otherwise, the appropriate ratio from figure 41 is applied to the first-approximation value of step f.

h. The adjusted snowpack value(s) from step f. or g. may need to be modified further for snowpack melt prior to snowmelt computation date (sec. 4.7.3.3). The value to be subtracted from a given snowpack value from step f. or g. is determined by the use of figure 40. The elevation and melt date (curved lines of fig. 40) are used to obtain the melt, if any, to be subtracted. This gives the melt-adjusted snowpack for a particular elevation.

   If the basin of concern involves a wide elevation range with accompanying large variation in adjusted snowpack values, the user should construct an elevation-adjusted snowpack curve to check consistency and make smoothing adjustments or interpolations, as necessary.

i. Apply snowmelt criteria (sec. 4.6) to snowpack from steps f., or g., if required, or h.

j. Go back to step d. with new PMP placement date and repeat remainder of stepwise procedure until a critical placement date of the 3-day PMP event for maximizing combined PMP and snowmelt has been determined.

k. (Optional) Use procedure outlined in steps a. through j. except instead of a mean elevation for the basin (step b.), use elevation increments or bands (i.e., making use of an area-elevation curve) if all snow at the lower elevations is apt to be melted in less time than the hydrologically critical time period.

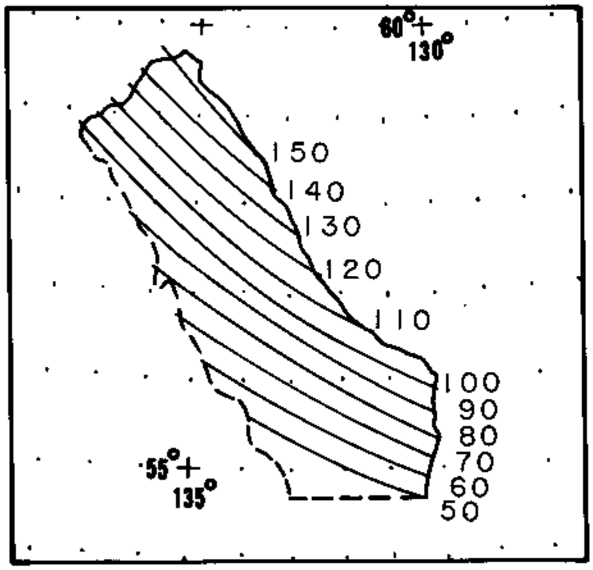


Figure 41.—Geographic variation of first approximation snowpack estimates (in percent).

4.7.5 Trial Computations and Comparisons.

The generalized stepwise procedure discussed in the previous section was used to compute snowpack for the following:

a. At grid points.

b. At grid points of high and low MAP.

c. Along lines starting upwind of glaciers and extending into glacier areas.

d. For numerous specific basins (using the mean elevation of the basin).

e. For some basins from among those in d. using the elevation variations in the basin.

f. For special locations where limited snow data and/or estimated snowmelt runoff were available.

These various computations were compared with previously summarized empirical data and results of studies (see section 4.7.2). Figure 43 shows a summation of computed snowpack values. These comparisons provide a means of evaluating the reasonableness of the procedure outlined for estimating snowpack. All computations of snowpack were made for May 15. One can see from figure 40 that for all cases with elevation of 3,000 feet (914 m) or above, the computed values did not need to be reduced for snowmelt. Below 3,000 ft (914 m) the user may use figure 40 to find how much melt (water equivalent) had to be subtracted from computed snowpack in individual cases.

From the many comparisons made, the following conclusions are noteworthy:

1. For Juneau, our procedure gives a snowpack water equivalent of near 30 in. (762 mm). This is based on

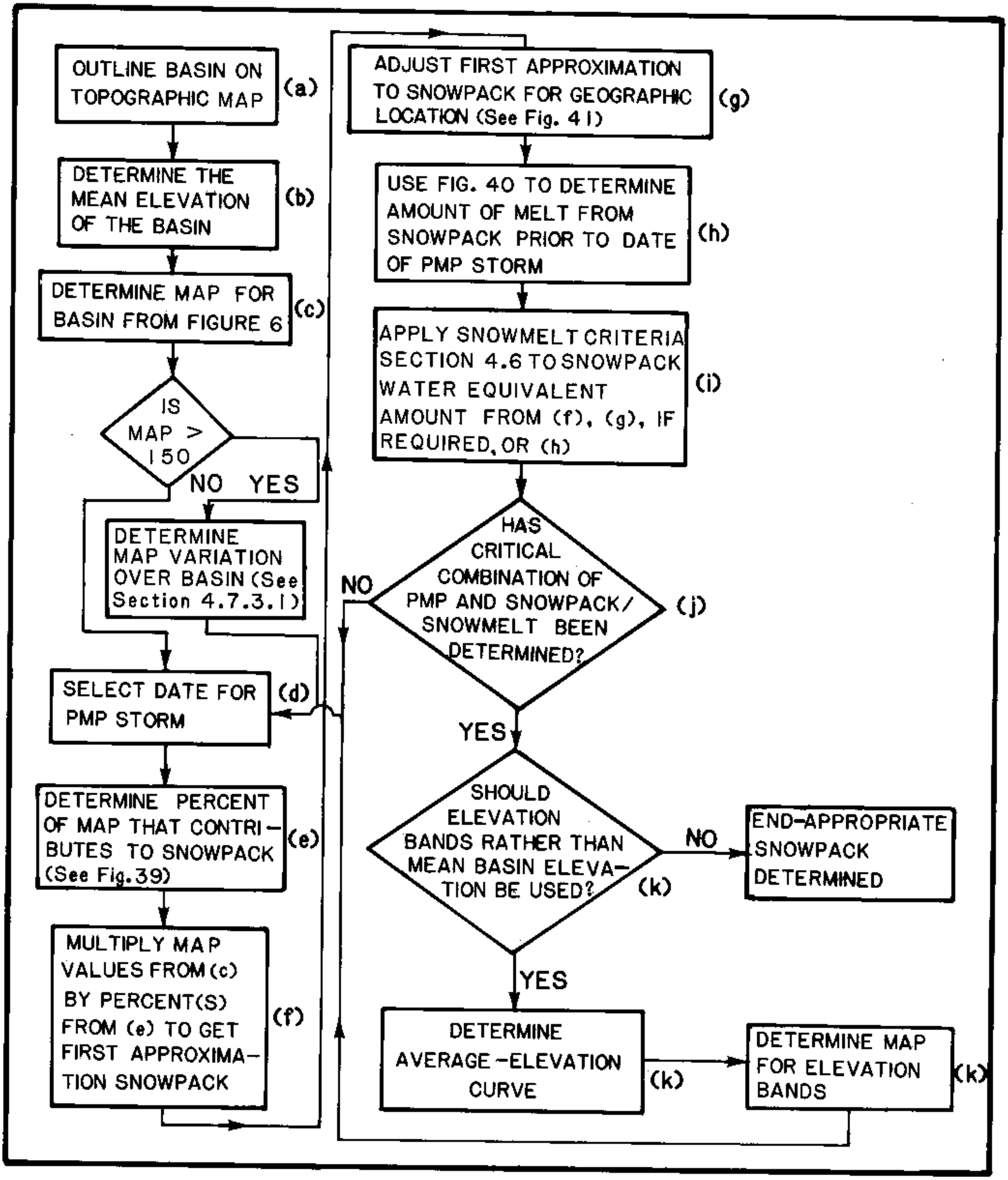


Figure 42.—Schematic of procedure to determine snowpack water equivalent for use with probable maximum precipitation.

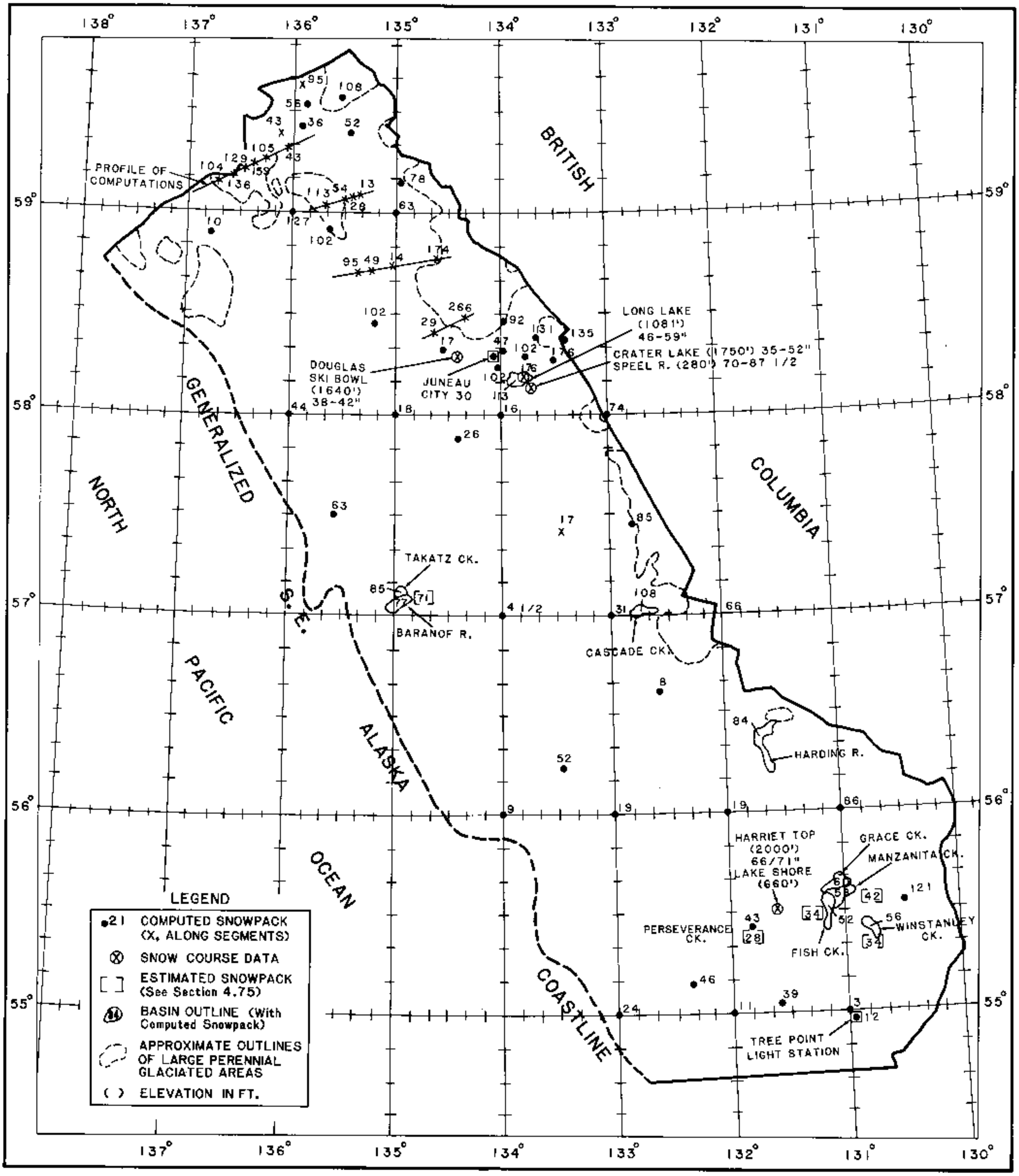


Figure 43.—Comparison of computed and observed snowpack values for various locations in southeast Alaska.

a a MAP of 93 in. (2362 mm) (fig. 6), a location factor of 1.34 (fig. 41), and an elevation factor of 0.24 (fig. 39) (93 x 1.34 x 0.24 = 29.9). This can be compared with an unadjusted synthetic season snowpack water equivalent of 17 in. (432 mm). By contrast, much farther south at Tree Point Light Station, similar computations give 98 x 0.5 x .24 or 12 in. (305 mm) and are compared to a synthetic season snowpack of 6.5 in. (165 mm). Thus, for low-elevation stations with close to 100 in. (2540 mm) of MAP but widely separated geographically in our study area, the relation of computed snowpack water equivalent to the synthetic-season snowpack is quite similar. We think this lends support to the regional adjustment factors of figure 41.

2. Considering the fact that the procedure for computing snowpack water equivalent (sec. 4.7.3) is set up so as not to generally overmaximize snowpack water equivalent at the higher elevations, the results near and upwind of glaciers agree quite well with the areas of glaciers or of no glaciers.

3. For a far-southerly location, Jumbo Mine, at 1,500-ft (457 m) elevation, a short record has indicated a mean snowfall of 448 in. (11379 mm) and an extreme 579 in. (14707 mm) in a year. If we assume that 10 in. (254 mm) of snow equals 1 in. (25.4 mm) of liquid equivalent, the extreme case would have a water equivalent of 58 in. (1473 mm), if it all accumulated. Computations with generalized MAP give about 34 in. (863 mm) which increases to about 39 in. (991 mm) using a MAP value of 196 in. (4978 mm) based on the short-record at Jumbo Mine. In such a comparison, we need to keep in mind our computation procedure uses a basin's MAP (when less than 150 in. (3810 mm) throughout the elevation range which maximizes snowpack water equivalent at the lower elevation while diminishing somewhat the extremes at higher elevations.

4. Resulting snowpack water equivalent values at the locations where snow course data were available compared quite favorably. This also applied (i.e., favorable comparisons) where estimated snowmelt values were made from basin runoff data.

4.8 Example of Use of Snowmelt Criteria

We shall go through an example using the 18-mi^2 (47-km^2) Takatz Creek basin. Specific elevations will be used covering the span of elevations in the basin. For temperatures and dew points, sample elevations only will be used. Ordinarily, for snowpack, due in part to the method used to maximize low-elevation snowpack, the use of a single mean elevation would produce similar results as the use of the mean of unweighted separate elevation computations. However, the user may wish to weight the elevation (or elevation bands) by means of an area-elevation curve (step k. in sec. 4.7.4). Also for trial computations at various time placements of the PMP, the low-elevation snowpack for late placements may all melt prior to the selected critical hydrologic period for the basin. In our example, we shall use a May 15 PMP placement. The basic procedure does not change for computations for other time placements of the PMP. The computation of snowpack follows the procedural concepts set forth in section 4.7.3, and summarized as specific computational steps in section 4.7.4 while section 4.6 and schematic figures cover the steps for computing temperatures, dew points, and winds.

4.8.1 Snowpack Determination

The following steps are required to determine the snowpack for the Takatz Creek basin:

a. The Takatz Creek basin is outlined in figure 4.

b. From a detailed topographic chart covering the Takatz Creek basin, we determine that elevations from sea level to 5,000 ft (1,524 m). (For later computations of actual snowmelt criteria, the user should determine a satisfactory depiction of orography in the basin).

c. Overlay the basin on MAP chart (fig. 6) and determine the average MAP for the basin. The average magnitude of the MAP will determine its use in the following fashion:

1. If the basin average MAP is less than 150 in. (3810 mm), the average MAP is used without elevation adjustment throughout the basin.

2. If the determined basin average MAP is equal to or greater than 150 in. (3810 mm), two-thirds of the basin average MAP is used at lowest basin elevation and four-thirds of the basin average MAP is used at highest basin elevation. Intermediate elevation values of MAP are then determined by assuming a linear variation of MAP with elevation.

   We determine a MAP of 225 in. (5715 mm) for the basin from figure 6. Since this is greater than 150 in. (3810 mm), we assign (see step 2 above) a MAP value of 150 in. (3810 mm) to sea level and 300 in. (7620 mm) to 5,000 ft (1,524 m). With linear variation between sea level and 5,000 ft (1,524 m) this gives 15 in. (381 mm) increase per 500 ft (152 m).

d. Using May 15 with figure 39 we read the following percents: SFC - 24; 500 ft - 29; 1,000 ft - 34; 1,500 ft - 39; 2,000 ft - 44; 2,500 ft - 49; 3,000 ft - 54; 3,500 ft - 58; 4,000 ft - 61; 4,500 ft - 64; and 5,000 ft - 67. (Note: Beyond 3,000 ft for a PMP date of May 15th, the percents come from extension of the intersection with the sloping elevation lines in the figure as the date is too early in the accumulation season at these higher elevations for the maximum snowpack to have yet been reached.)

e. The MAP at the 500-ft incremental elevations from step c. are now each multiplied by the respective elevation percents from step d. The MAP, ratios of snowpack water equivalent to MAP, and unadjusted snowpack water equivalent are shown in columns (2), (3), and (4) of table 22, respectively.

Table 22.--Preliminary snowpack computations for 500-ft (152 m) elevation increments for Takatz Creek basin

(1) Height (ft) sea level	(2) MAP (in.)	(3) Ratio	(4) Snowpack (in.)	(5) Regionally adjusted snowpack (in.)
sea level	150	.24	36.0	32
500	165	.29	47.9	43
1,000	180	.34	61.2	55
1,500	195	.39	76.0	68
2,000	210	.44	92.4	83
2,500	225	.49	110.2	99
3,000	240	.54	129.6	117
3,500	255	.58	147.9	133
4,000	270	.61	164.7	148
4,500	285	.64	182.4	164
5,000	300	.67	201.0	181

f. From figure 41 the ratio for the Takatz Creek basin is 0.9. The unadjusted snowpacks computed in step e. are now multiplied by 0.9. The results are shown in column (5) of table 22.

g. Based upon required snowmelt up to May 15 from figure 40 the regionally adjusted values in table 22 up to 2,500 ft (last incremental elevation needing a prior melt adjustment from figure 40) need to have appropriate melt subtracted. The melt-adjusted values are shown in table 23.

Table 23.—Final snowpack values for 500-ft (152 m) elevation increments Takatz Creek basin

Elevation (ft)	Regionally adjusted snowpack (in.)	Melt	Melt adjusted snowpack (in.)
Sea level	32	10	22
500	43	9	34
1,000	55	7	48
1,500	68	6	62
2,000	83	4	79
2,500	99	2	97
3,000	Same as regionally adjusted values in table 22		

4.8.2 Temperature Criteria Prior to Probable Maximum Precipitation

Due to the frequency with which temperatures and dew points will be given in subsequent sections, particularly where long sequences are involved, the values will be given in degrees Fahrenheit only. The user may obtain celsius equivalents with the formula: $C = \frac{5}{9}(F-32)$.

a. Since we chose May 15 for our example, we read from figure 31, 46°F.

b. For the high-temperature case (using departures shown in figure 33), a sequence of temperatures beginning 6 days prior to the first day of the 3-day PMP event will be 56°, 58.5°, 53.5°, 52°, 52° and 52°F. [Note: If the mean temperature for any day were to exceed 62°F, 62°F temperature would be used for that day (sec. 4.2.3, fig. 33)]

c. For the high-dew-point case, the temperatures for beginning 6 days prior to first day of the 3-day PMP event are: 51°, 51°, 49°, 48°, 48° and 48°F.

d. In applying elevation adjustments (fig. 33), we shall work with a single elevation, 1,000 ft, since corrections for other elevations would simply be at the same rate. Hence, for 1,000 ft, subtracting 4°F from the readings in step b. gives, 52°, 54.5°, 49.5°, 48°, 48° and 48°F for the high-temperature case. Likewise, in subtracting 3°F from the high-dew-point sequence, we get for 1,000 ft, 48°, 48°, 46°, 45°, 45°, and 45°F.

4.8.3 Dew-Point Criteria Prior to Probable Maximum Precipitation

a. Dew points for the high-temperature case come from the adjustments on figure 35. For a 6-day sequence prior to the first day of the 3-day PMP event, the adjustments are -18°, -18°, -18°, -13°, -13° and -13°F. Application of these adjustments to the high-temperature case values of section 4.8.2.d gives the dew-point sequence: 34°, 36.5°, 31.5°, 35°, and 35°F.

b. Dew points for the high-dew-point case also come from adjustments on figure 35 and are -8°, -8°, -6°, -4°, -4° and -4°F. Application of these adjustments to the high-dew-point case values of section 4.8.2.d gives the dew-point sequence 40°, 40°, 40°, 41°, 41°, and 41°F.

4.8.4 Temperature and Dew-Point Criteria During the Probable Maximum Precipitation

As pointed out in section 4.6.3, the temperatures during the 3-day PMP event are determined by the dew points.

a. Variation of mean dew point over a few days is slight. We shall read the maximum 1-day dew point applicable for May 15 from the mid-May map of figure 34. We read 50.5°F. This is both dew point and temperature.

b. Since our PMP date is May 15, we do not need to develop a smooth curve through values for successive months and interpolate for the desired date.

c. Subtracting 2°F (step $c._3$, fig. 35, and sec. 4.6.3) from 50.5°F gives 48.5°F for the second highest rainfall day of the PMP. This is both dew point and temperature.

d. Subtracting 4°F (step $d._3$, fig. 35, and sec. 4.6.3) from 50.5°F gives 46.5°F for the third highest rainfall day of the PMP. This is both dew point and temperature.

e. The three days of dew points and temperatures adjusted for a 1,000-ft elevation are 47.5, 45.5, and 43.5°F (i.e., -3°/1,000 ft) applied to temperatures in a., c., and d. of this section.

4.8.5 Half-Day Values of Temperatures and Dew Points

a. During the 3-day PMP event, half-day (maximum and minimum dew points) values come from applying ± 2°F and are, therefore, 48.5° and 52.5°F (maximum day of PMP) 46.5° and 50.5°F, and 44.5° and 48.5°F (lowest day of PMP). Likewise, for the 3 days of maximum and minimum temperatures during PMP, we get by applying ±2°F, 48.5° and 52.5°F, 46.5° and 50.5°F, and 44.5°

and 48.5°F. The 1,000-ft values are obtained by subtracting 3°F from all of the above values.

b. For half-day dew points for the high-temperature case prior to the 3-day PMP event, we apply ± 3°F to the values of step a, section 4.8.3. Thus, we get 35° and 41°F, 37.5° and 43.5°F, 32.5° and 38.5°F, 36° and 42°F, 36° and 42°F, and 36° and 42°F. The 1,000-ft values are obtained by subtracting 4°F from all the above values.

c. For half-day dew points for the high-dew-point case prior to the 3-day PMP event, we apply ± 2°F to the values of step b. of section 4.8.3. Thus, we get 41° and 45°F, 41° and 45°F, and 41° and 45°F, 42° and 46°F, 42° and 46°F, and 42° and 46°F, The 1,000-ft values are obtained by subtracting 3°F from all of the above values.

d. To obtain half-day temperatures for the high-temperature case prior to the 3-day PMP event, we apply ± 9°F to the values of step b., section 4.8.2. Thus, we get 47° and 65°F, 49.5° and 67.5°F, 44.5° and 62.5°F, 43° and 61°F, 43° and 61°F, and 43° and 61°F. The 1,000-ft values are obtained by subtracting 4°F from all of the above values.

e. To obtain half-day temperatures for the high-dew-point case prior to the 3-day PMP event, we apply ± 6°F to the values of step c., section 4.8.2. Thus, we get 45° and 57°F, 45° and 57°F, 43° and 55°F, 42° and 54°F, 42° and 54°F, and 42° and 54°F. The 1,000-ft values are obtained by subtracting 3°F from all above values.

4.8.6 Wind Criteria

4.8.6.1 Winds During Probable Maximum Precipitation. Except for determination of barrier adjustments explained in section 4.4.1.2, the wind criteria both for prior to and during PMP may be determined from following the wind schematic of figure 36. We shall develop the wind criteria for the Takatz Creek by a stepwise procedure.

a. The no-barrier all-season 3 days of PMP wind are 36, 28, and 25 mph (16.1, 12.5 and 11.2 m/s), respectively. For May 15, our placement date, these values reduce to 33, 26, and 23 mph (14.8, 11.6, and 10.3 m/s), (i.e., 92 percent of the April values).

b. Using the generalized barrier chart (fig. 5), lines are drawn from the center of the basin to the coast toward the following directions: 256°, 229°, 202°, 175°, and 148°. The maximum barriers intersected along each of these lines to the coast are read from figure 5. These are estimated to the nearest 500 ft (152 m), 5,000, 4,000, 3,500, 3,000 and 3,000 ft (1,524, 1,220, 1,067, 914 and 914 m). The mean of these elevations is 3,700 ft (1,128 m). Therefore, we reduce the basic winds for the 3 days of the PMP event by 18.5 percent (i.e., 3.7 x 5). This gives 27, 21, and 19 mph (12.2, 9.4, 8.5 m/s) for barrier-adjusted values.

c. Since the elevation adjustment of winds is nonlinear (unlike the adjustments for temperature and/or dew point), we shall compute winds for two separate elevations, 1,000 and 5,000 ft (305 and 1,524 m) to adequately illustrate the procedure. For 1,000 ft (305 m), the winds for the 3-day PMP event are (using 107 percent from figure 36) 29, 22 and 20 mph (13.0, 9.8, and 8.9 m/s). The 5,000-ft winds are (using 225 percent from figure 36) 61, 47, and 43 mph (27.3, 21.0, and 19.2 m/s)

4.8.6.2 Winds Prior to Probable Maximum Precipitation

a. For the high-temperature case, the basic May 15 maximum 1-day wind for the PMP event of 33 mph (14.8 m/s) (step $a._1$, section 4.8.6.1) is multiplied by the following percents (fig. 36) for a wind sequence beginning 6 days prior to the 3-day PMP event: 29, 29, 29, 19, 55 and 42. This gives for sea level a sequence of winds of 10, 10, 10, 6, 18 and 14 mph (4.5, 4.5, 4.5, 2.7, 8.0, and 6.3 m/s).

b. The high-temperature case 1,000-ft (305-m) (102 percent, fig. 36) and 5,000-ft (1,524-m) (134 percent, fig. 41) winds are: 10, 10, 10, 6, 18 and 14 mph (4.5, 4.5, 4.5, 2.7, 8.0, and 6.3 m/s) and 13, 13, 13, 8, 24, and 19 mph (5.8, 5.8, 5.8, 3.6, 10.7, and 8.5 m/s), respectively.

c. For the high-dew-point case, the basic May 15 maximum 1-day wind for the 3-day PMP event of 33 mph (14.8 m/s) is multiplied by the following percents (fig. 36) for a wind sequence beginning 6 days prior to the 3-day PMP event: 29, 29, 29, 32, 65, and 55. This gives a sea-level sequence of winds of 10, 10, 10, 11, 21, and 18 mph (4.5, 4.5, 4.5, 4.9, 9.4, and 8.0 m/s)

d. The high-dew-point case 1,000-ft (305-m) (107 percent, fig. 36) and 5,000-ft (1,524-m) (225 percent, fig. 36) winds are: 11, 11, 11, 12, 22, and 19 mph; (4.9, 4.9, 4.9, 5.4, 9.8, and 8.5 m/s) and 22, 22, 22, 25, 47, and 40 mph (9.8, 9.8, 9.8, 11.2, 21.0, and 17.9 m/s), respectively.

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REFERENCES

Anderson, E., National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 1977: personal communication.

Environment Canada, 1973: Canadian Normals, Precipitation, 1941-1970. Vol. 2, Downsview, Ontario, Canada, 330 pp.

Environmental Data Service, 1973: Monthly Normals of Temperature Precipitation and Heating and Cooling Days, 1941-1970, Climatography of the United States, No. 81 (Alaska), National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Asheville, NC, 7 pp.

Brower, William A., Jr., Diaz, Henry F., Precktel, Anton S., Searby, Harold W., and Wise, James L, 1970: Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska: Volume 1, Gulf of Alaska. Environmental Information and Data Center, University of Alaska, Anchorage, Alaska, and National Climatic Center, Environmental Data Service, National Oceanic and Atmospheric Administration, Asheville, NC, 439 pp.

Freeman, T.B., 1970: Summary of Snow Survey Measurements for Alaska, Soil Conservation Service, U.S. Department of Agriculture, Anchorage, Alaska, 101 pp.

Hansen, E. Marshall, and Schwarz, Francis K., 1977: Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainage. Hydrometeorological Report No. 49, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 161 pp.

Hydrometeorological Branch (Office of Hydrology, Weather Bureau, U.S. Department of Commerce, Washington, D.C.) 1961: Probable Maximum Precipitation for Bradley Lake Basin. Unpublished manuscript, 23 pp.

Hydrometeorological Branch (Office of Hydrology, Weather Bureau, U.S. Department of Commerce, Washington, D.C.) 1962: Estimates of Probable Maximum Precipitation and Snowmelt Criteria for Chena River Basin, Alaska. Unpublished manuscript, 42 pp.

Hydrometeorological Branch (U.S. Weather Bureau, U.S. Department of Commerce, Washington, DC), 1965: Preliminary Estimates of Probable Maximum Precipitation and Snowmelt Criteria for the 302- Square Mile Long Lake Portion of the Snettisham Project. Unpublished manuscript, 15 pp.

Hydrometeorological Branch (Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Washington, DC), 1967: Estimates of Probable Maximum Precipitation and Snowmelt Criteria for Takatz Creek, Baranof Island, Alaska. Unpublished manuscript, 18 pp.

Hydrometeorological Branch (National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD), 1974: Probable Maximum Precipitation for Four Watersheds Near Ketchikan, Alaska. Unpublished manuscript, 7 pp.

Hydrometeorological Branch (National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD), 1975: Tentative Estimates of Probable Maximum Precipitation (PMP) and Snowmelt Criteria for Four Susitna River Drainage. Unpublished manuscript, 15 pp.

Kilday, Gordon, D., 1974: Mean Monthly and Annual Precipitation Alaska, NOAA Technical Memorandum NWS AR-10, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Anchorage, Alaska, 13 pp.

Klein, W. H., 1957: Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere. Research Paper No. 40, Weather Bureau, U.S. Department of Commerce, Washington, DC, 60 pp.

Miller, J. F., 1963: Probable Maximum Precipitation and Rainfall-Frequency Data for Alaska. Technical Paper No. 47, Weather Bureau, U.S. Department of Commerce, Washington, DC, 69 pp.

Miller, J. F. 1965: Two- to Ten-Day Precipitation for Return Periods of 2 to 100 Years in Alaska. Technical Paper No. 52, U.S. Weather Bureau, U.S. Department of Commerce, Washington, DC, 30 pp.

Ratner, Benjamin, 1957: Upper-air Climatology of the United States. Part I. Averages of Isobaric Surfaces-Height, Temperature, Humidity and Density. Technical Paper No. 32, U.S. Weather Bureau, U.S. Department of Commerce, Washington, DC, 199 pp.

Sanford, Henry R., National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Anchorage, Alaska, 1977: Personal communication.

Schreiner, Louis C., and Riedel, John T., 1978: Probable Maximum Precipitation Estimates, United States East of the 105th Meridian. Hydrometeorological Report No. 51, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D. C., 87 pp.

Thompson, H. J., 1947: Climate of Southeast Alaska, in Water Powers Southeast Alaska, Federal Power Commission and Forest Service, U.S. Department of Agriculture, Washington, DC, pp. 13-27.

U.S. Weather Bureau 1961: Interim Report, Probable Maximum Precipitation in California, Hydrometeorological Report No. 36, U.S. Department of Commerce, Washington, DC, 202 pp.

U.S. Weather Bureau, 1965: Mean Annual Precipitation, 1930-1957, State of Washington. Soil Conservation Service, U.S. Department of Agriculture in cooperation with Weather Bureau, U.S. Department of Commerce, Portland, OR, 1 sheet.

U.S. Weather Bureau, 1966a: Meteorological Conditions for Probable Maximum Flood on the Yukon River Above Rampart, Alaska. Hydrometeorological Report No. 42, Environmental Science Services Administration, U.S. Department of Commerce, Washington, D.C., 97 pp.

U.S. Weather Bureau, 1966 b: Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, U.S. Department of Commerce, Washington, D. C., 226 pp.

Walker, Edward R., 1961: A Synoptic Climatology for Parts of the Western Cordillera. Publication in Meteorology No. 35, McGill University, Montreal, Canada, 218 pp.

World Meteorological Organization, 1969: Estimation of Maximum Floods. WMO No. 233, TP 126, Technical Note No. 98, Geneva, Switzerland, 288 pp.

APPENDIX A

Summary of the Availability of Streamflow Records for Southeast Alaska

Streamflow data from various sources were collected, reviewed, summarized, and compared. Water Supply Paper No. 1372 (U. S. Geological Survey, 1957) summarized streamflow data through September 1950 on an hourly and yearly basis. A bar chart on page 15 of this report summarized the available data. Some miscellaneous early records that this paper did not include may be found in a Federal River Commission Report (Federal Power Commission and U.S. Department of Agriculture, 1947). These are identified in table 2. Except for these early records, stream gaging numbers are assigned by the U.S. Geological Survey.

Water Supply Paper No. 1372 summarizes by daily and monthly discharges the records for the years 1946-50. This summation in report 1372 includes examination and correction of computational errors previously made. In some cases where revision was considered necessary but not possible to accomplish, the record was eliminated. On the other hand, wherever possible, estimates of streamflow were made to "fill short gaps to complete the continuity of record."

The period 1950 to September 1960 was covered in Water Supply Paper No. 1740, while Water Supply Paper No. 1936 covers the 1960 to 1965 period. These water supply papers give daily discharges. Mean discharges are given for only those gaging stations with 5 years or more of record. Since 1965 streamflow data are obtained from annual copies of Water Resources Data for Alaska. (U.S. Geological Survey, various years)*.

*U.S. Geological Survey, 1966-1974: Water Resources Data for Alaska, Part I Surface Weather Records Data for Southeast Alaska, Department of Interior.